DOCUMENT RESUME

ED 061 953 LI 003 618

TITLE	Primary Scientific Publication; A Report Prepared (With Special Reference to Physics) for the UNESCO Ad-Hoc Sub-Committee on Methods of Primary Scientific Publication and for the ICSU--UNESCO Joint Study on the Communication of Scientific Information and on the Feasibility of a Worldwide Science Information System.
INSTITUTION	International Council of Scientific Unions, Paris (France).; United Nations Educational, Scientific, and Cultural Organization, Paris (France).
PUB DATE	2 Oct 67
NOTE	105p.;(4 References)
EDRS PRICE	MF-$0.65 HC-$6.58
DESCRIPTORS	Definitions; Information Dissemination; *Information Networks; Information Processing; Information Science; *Information Systems; *International Programs; Periodicals; *Physics; *Publishing Industry
IDENTIFIERS	Primary Literature; *Scientific and Technical Information; Secondary Services

ABSTRACT

The data used for this report was prepared mainly from correspondence as described in the introduction, Chapter I. The manufacture, distribution and processing of original scientific information today is considered in Chapter II. This Chapter is devoted to the tasks of establishing precise definitions of the vocabulary used in the field (e.g. Communication, Information, Documentation, Papers, Notes, Letters, etc.) and to an attempt to give a rough classification of scientific journals as they exist at present. Chapter III describes the growth of primary journals as seen through the evolution of a sample and Chapter IV is concerned with the evolution of original scientific literature as seen through some of the major abstracting periodicals. Chapter V is devoted to an examination of the evolution of the present situation of scientific information problems, together with a brief study of some attempts or proposals to deal with these problems by either evolutionary or revolutionary procedures. A brief conclusion to the report appears as Chapter VI. (Author/NH)

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PRIMARY SCIENTIFIC PUBLICATION

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(With special reference to Physics)
for
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on Methods of Primary Scientific Publication
and for the
ICSU-UNESCO Joint Study on the
Communication of Scientific Information
and on the Feasibility of a Worldwide Science Information System

LI 003 618

October 2, 1967

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I - INTRODUCTION

The present paper has been prepared by the Rapporteur of the UNESCO Ad-Hoc Sub-Committee on Methods of Primary Scientific Publication. The task assigned to the Committee tended to elicit and to evaluate proposals aiming at the improvement of conventional publication techniques and at the introduction of new modes of publication and dissemination of scientific research papers (1).

The Committee's work was mainly prepared by correspondence, correspondence in which all the members of the Sub-Committee readily took part. It very soon appeared that the adequacy of the Committee's efforts would have been greatly enhanced if a sufficiently thorough and quantitative survey of at least the principal aspects of the present situation could first have been made. The magnitude of such a task was evidently beyond the means of the Sub-Committee; however, coming to the conclusion that the drafting of his report in the complete absence of quantitative data was well-nigh impossible, the Rapporteur attempted to assemble such data in the local cases of narrowly defined samples, all confined within one or two limited chapters of the realm of Natural and Exact Sciences: Chapters III and IV of this present report are devoted to this task.

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(1) More specifically, the Rapporteur was to gather information, solicit ideas and co-ordinate relevant proposals advanced by the Members of the Sub-Committee concerning ways of improving the present system of publication of original scientific research papers, taking into consideration the customary manner in which such papers are processed and presented in secondary (indexing and abstracting) Journals.

The correspondence between the Members of the Sub-Committee also showed the importance of establishing precise definitions of the vocabulary used in the field (e.g. Communication, Information, Documentation, Papers, Notes, Letters, etc..) and of making an attempt to give a rough classification of Scientific Journals as they exist at present : Chapter II is devoted to these tasks which proved not to be as simple as they may seem to the scientist-at-large.

Chapter V is devoted to an examination of the evolution of the present situation of Scientific Information Problems, together with a brief study of some attempts or proposals to deal with these problems by either evolutionary or revolutionary procedures. A brief conclusion to the report appears as Chapter VI .

In its present form, the reader will be justified to judge that the report does not fulfill the ambitions nor attains the universal goal which had been set at the founding of the Sub-Committee : it is too localized and it suffers from the fact that most of the quantitative examples given concern the field of the Physical Sciences. However, the Rapporteur and the Members of the Sub-Committee will feel that their efforts have been well rewarded if their work helps to define the depth and scope of further studies.

The so-called "problems of Scientific Information" are not, by essence, new. Tradition records that, sometime during the last twenty years of the XIXth century, a celebrated British man of science remarked that he often found it easier to arrive at a certain information by direct experiment rather than through a tedious search in the Library for some obscure paper published at an unknown date ...

Since the end of the XVIIIth century, when Science ceased to be the noble and philosophical care of isolated gentlemen, the mass of recorded scientific information, the number of scientists who produce this information, the number of persons who should be informed have been steadily growing with time .

What is new is that the rate of this growth has been greatly increased, in several rather well-defined stages, in the course of the last fifty years. Consequently, but with an important lag, realization came that something should be done to procure more powerful means to deal with these quickly increasing quantities - and that this something had better be attempted on an international basis. UNESCO and the Royal Society share the merit to have initiated this; it is in 1948 that UNESCO sponsored, organized and convened in Paris the first World Conference on Scientific Information . Since then, efforts - both National and International - have been ceaseless though they could have been better co-ordinated.

Committees on Scientific Information publication and distribution have been established in many countries; proposals for improvement, stated usually in very general (and non quantitative) terms, have not been very numerous; actual improvements have been limited. The advent of electronic computers, the realization that these new tools could be used with advantage to deal with the storage, sorting and retrieval of large amounts of information have acted for a short period as a tonic to strengthen these efforts. Unhappily, international co-operation has scarcely been improved and universal standardization, even in the simplest cases, remains almost unconceivable. As an extreme example, let us remember that after more than 14 years discussions, we still have no Internationally recognized rules for the abbreviation of the names of Scientific Periodicals in bibliographic references .

In some of their aspect, there is a curious likeness between the "Problems of Scientific Information" and the problems of automobile circulation on the roads of the world : in both cases, the quantity which has to be shifted or distributed is increasing swiftly, while the main basic structures and ideas remain substantially unchanged; - in both cases, the increase of this quantity is encouraged by the bodies or governments responsible for the Economic and Scientific expansion of their own countries, while the improvement , development or replacement of the basic structures which allow transportation or distribution is neglected or left lagging far behind; - in both cases, the "user" or "consumer" in its droves, shows curiously unrealistic attitudes towards the deteriorating situation, one arising from the intimate conviction that too much noise is made about a trifling or quasi non-existent inconvenience ("I have personally no trouble in getting all the information I want.."), another one consisting, on the contrary, of emphatically claiming that a radical and complete revolution must, in all possible haste, establish a perfect (i.e. infinitely swift, complete and selective) World System of Scientific Information Production and Distribution .

The "problems of Scientific Information" are human problems and the present report is an unpretentious but, it is hoped, honest attempt to look at some of them from a human science point of view, avoiding extrapolation or unvalid generalizations of scientific reasonings and conclusions - a serious attempt being nevertheless made to show that it is possible to define the size, limitations and costs of the quantities with which we are dealing. The report needs not be read by anyone not prepared to admit that the literature of scientific research is, in itself, an important subject of research .

II - ORIGINAL SCIENTIFIC INFORMATION TO-DAY: MANUFACTURE, DISTRIBUTION AND PROCESSING

Semantics

In the course of the analysis of the literature dealing with a human problem, the study of terminology may often be very revealing. Such is the case here; let us devote a little space to the consideration of the meaning of three words : Communication, Information, Documentation.

Communication : The word is derived from a low-latin root which originally meant "to put something in common" and this original meaning applies correctly to intellectual communication. Full, complete communication between two minds is probably an unattainable limit : human languages spoil and pollute the meaning conveyed just as the coded signals of telecommunication systems are spoiled and polluted by thermal noise and distortion.

From this point of view, one could assert that written communication has its own special drawbacks; the message contained in a written communication has been separated from the spectacle of the man who conveys the message : the attitude of this man, his facial expression, the modulation or inflection of his voice, all this would add to the message many suggestions which would help interpretation; the written message does not contain them. Also the degree of attention, the depth and constancy of this attention are more fragile than the attention which a gifted speaker would get from the same person.

Teaching is an activity which must have been going on for at least 3,000 years : during this time interval, schools, universities, academies have insisted in maintaining the tradition of oral communication, sometime so rigidly as to petrify their teaching. It is quite true that from time to time some brilliant mind will propose to do away with lectures and to confine all teaching to written communication; it is true that Carlyle once wrote that the true University is a collection of books. However, lectures go on and any man connected with politics or commerce knows intensely that direct oral propaganda is more powerful than its written variety.

The preceding remarks concern the human mind in general and therefore should apply to the scientific communication domain : this is the main reason why there exists and there will always exist frequent gatherings of scientific groups: the main purpose of a scientific Congress, if the afore-said remarks are accepted, is, therefore, not to produce large volumes of proceedings, but to provide direct contact between men interested in the same subjects.

Information : What is meant by the expression "scientific information" ? More specifically, what is one scientific information ? A little thought will show that a scientific information is not necessarily the expression of a scientific fact. It should be, of course, and this is what its author intends it to be, but the reality and correctness of the facts supposedly expressed in the information cannot be accepted as finally established before confirmation by other people working in the same domain and who will have arrived at the same conclusions independently and, if possible, by using other methods .

Documentation : While most scientists and laboratory research workers speak of scientific information, most librarians and related specialists will only use the words "documents and documentation". These two words correspond to a profoundly different attitude : the document for the library man and for the humanist, who, for a long time, were the only ones to be interested in it, is something tangible; it has a permanent value, a solid volume. It can be stocked, put away, classified and through this, retrieved; the orderly organization of these activities is an end in itself. Differently, the research scientist will consider that the document is a part of his equipment, in the same way as a galvanometer used to be and a screwdriver still is. There should be no question of taking time to look for it : the relevant document should fall of itself under the eyes of the competent reader ... For this reader also, the information value of the scientific document has no permanent character; it is as a rule, a decreasing function of the time which elapses from the day the document was printed and distributed. In this way, one may speak of a mean life for the information contained in a scientific document; this mean life varies within wide limits, as does the mean life of radio-active elements. Nowadays, the laboratory man never opens a XVIIIth century or even a XIXth century book ; he knows the contents of a few XIXth century major papers because these contents were taught him at the University but, as a rule, he has never seen their original text. The average life of most scientific documents published during the XXth century varies between a few decades and few months : in extreme cases, a few weeks.

As time passes, the librarian and documentalist's point of view gradually supersedes the scientist's attitude. The enormous printed mass of original scientific literature abandoned by the researcher and the professor does not become useless and it is still necessary to keep it stocked (though perhaps not in the same place) and to retrieve it (though perhaps not by the same methods); the public to whom these scientifically obsolete documents are still of value changes : the number of readers decreases swiftly and tends towards a small remainder of historians and philosophers. We see that the point of view of the librarian dealing with documents and the point of view of the scientist dealing with information can never coincide .

Not only is a "scientific information" devoid, in most cases, of a permanent value; it is also often expressed in a language which is intelligible only temporarily and sometimes locally : science in progress changes its language and what is worse is that the meaning given to words by the scientist may be subject to surprising variations in the course of the elaboration of renewed concepts. It may happen that two contemporary scientists will use the same expression in two completely different senses, senses which are not defined anywhere and can be got at only from their articles, often after long meditations : in this respect, the language of scientific information has the same weaknesses as the language of philosophy. The fact that philosopher and scientist are both proud of their vocabulary is not in contradiction with this .

Nowadays, we have to compare the vocabularies and associated concepts of scientists writing in ten or more languages: the correct translation of documents containing scientific information is one of the most complex undertakings that can be found in the field of intellectual exchange. Again the somewhat naive attitude of research workers towards automatical translation is not in contradiction with this .

The Paper

We have just remarked that a statement of scientific information is not necessarily the statement of a scientific fact : a scientific fact will only be established when other workers acting independently will have checked and reproduced the alleged fact described by the first authors. It should be realized that this does not mean any disbelief or lack of confidence, but only that such verification is an obligation of a correct scientific method : it is necessary to demonstrate that the influence of what can be called accidental parameters (e.g. time, place, psychology of the authors and observers, ideosyncrasies of their apparatus ...) is really insignificant.

If we accept this, it follows that an original scientific paper (in French : "Mémoire Scientifique") contains scientific information only when it has been drafted in such a way that a research worker trained in the field will be able, from directions given in the paper, to repeat the experiments described and to secure the results described with equal accuracy or within the lumits of experimental error specified by the authors : such could be the definition to-day of an original scientific paper .

A little thought will show, however, that the definition cannot be valid everywhere inside the vast province of Exact and Natural Sciences : it can only hold when and where the scientist is dealing with phenomena which he produces or reproduces more or less at will : such is the case for a chemical reaction, such is not the case for an earthquake and we come thus to the conclusion that in the realm of purely descriptive science it is always difficult to assess the value of what is still called, by extension, an original scientific paper .

It should be understood that we have no intention to deny the value of "papers" which do not conform to the above definition; we only wish to point out that such documents bring to their readers what we would call scientific news and that such news will have, in the scientific world, the impact that ordinary news (e.g. political) have in the general domain. For instance, let us suppose that somebody writes that he has succeeded to synthetize diamond : this is a scientific news. If his paper describes correctly and fully the operations which led him to this synthesis, we are in presence of new scientific information. When a French magistrate of the XVIIth century negligently wrote the statement universally called to-day the last of Fermat's theorems, he was announcing a scientific news which the combined efforts of mathematicians through three centuries have been unable to transform into scientific information .

The scientific paper has a long history which will not be considered here for the sake of brevity. To-day, the paper generally appears as the final form of a succession of texts more or less detailed, more or less explicit; when the distribution of such texts is confined to a restricted part of the scientific world, we shall say that we are concerned with internal reports ; when the text is available to the public at large, we shall speak of a preliminary publication.

The advent of internal reports is mainly the consequence of an evolution in the structure of the world of research : in the first half of the XIXth century, the scientific paper was an essay written by a solitary research worker , read during a sitting of, and published in the proceedings of, a learned Society or Academy for the enlightenment and edification of its Fellows. To-day, scientific information originates in a team of scientists working most often in a large research institution subsidized by national, regional or private funds : before it is released in the shape of a classical scientific paper, it has to get approval and permission from various authorities judging according to industrial, political, financial and prestige criteria : internal reports are used both for the edification of these authorities and for the instruction of other workers inside the group to which the reports are restricted.

We shall not analyse further these aspects which can be considered as outside the scope of the Report and which have been considered in other publications.

Preliminary Publications

In most cases nowadays, getting approval for the text of a scientific paper and permission to publish the said paper will take some time : a time which must be added to the unavoidable delay arising from the procedures of acceptance by a journal, and from printing and distribution. This increased inertia of scientific information circulation occurred at a time when important accelerations characterized the output of many domains of scientific research. This coincidence explains why preliminary publications, which have existed throughout the history of science (1) have proliferated so intensely during the last 20 years.

It should be clear, by now, that a preliminary publication essentially consists in an announcement of scientific value, the text containing insufficient data for the independent verification of the statement. Hence, a later scientific paper should be published on the same subject and this paper should refer to the preliminary publication in question .

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(1) See note 2, page 11.

The reader will realize that according to the present definition, Letters to the Editor are not always preliminary publications : a few of them are scientifically complete, though short, and should therefore rank as normal original scientific papers : they are published as Letters to the Editor only to save time; also, a certain proportion of Letters to the Editor will never be completed by any other publication on the same subject and from the same authors (1); these should be considered as statements pure and simple ,a cryptic form of publication which dates back to the XVIIth century (2).

Scientific statements to-day are also made to the public at large through Press Conferences, a procedure very similar to political press conferences .

Review Articles

Scientific Papers and Primary Publications in very many cases provide "localized" Scientific Information . Before these scattered, analytic-type informations can be knitted together by a coherent theory, there is always a great need of what we shall call here "review articles" in which the author attempts to reach a degree of synthesis by the systematic examination and criticism of the informations to be found in original papers dealing with a certain limited domain of research.

Strictly speaking, may we say that Review Articles belong to the field of Primary Scientific Information ? The answer is far from simple. A really synthetic attempt to group into a family certain isolated facts ascertained one by one by independent authors and suggesting that a plausible explanation may be found by taking as a starting point a certain hypothesis is evidently entitled to be called creative work of high value. Insipid juxtapositions of facts diluted in a schoolboy variety of binding text and followed by plethoric bibliographies are not, though they may be useful. Since this report already threatens to grow to a sizeable bulk, we shall a priori consider that Review Articles are outside its scope.

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(1) Often in spite of specific promises made in the text of the Premilimary Publication.

(2) Pascal, Newton, the Bernoullis and many others were fond of this sort of announcement, the historical consequences of which have not always been happy.

Primary Scientific Journals

When liberated (i.e. declassified) (1), the paper or preliminary publication will eventually appear in printed form, available to the public at large. In the majority of cases, it will be included in an issue of a Primary Scientific Journal ; less frequently, it will be published single or accompanied by other texts as a pamphlet, part of a serial collection of publications, sometimes numbered accordingly. The publication of major scientific information in totally independent and isolated pamphlets is happily to-day practically non existent. The last outstanding example seems to be Sadi Carnot's "Réflexions sur la puissance motrice du feu", published in 1824.

Primary Journals, to-day very numerous, do not conform to a single type in their appearance and behaviour. For the convenience of the reader, we shall try to get the majority of them to fit into a rough classification recognizing four main categories :

- "National Journals" (class I)

These were the first journals to appear in the scientific world. At the beginning of the XVIIth century, a handful of cultivated men, interested in what came to be called "Natural Philosophy" were sprinkled all over Europe. Their only practical means of intellectual communication (journeys were rare undertakings) was to write and to exchange letters. However, most of these men showed little interest in such intercourse and often behaved as if there was no justifiable interest to be served by putting the result of their works before the general public. There were two reasons for this quaint attitude :

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(1) The word is taken here in its most extensive sense.

a) The "general public", in those days, meant little ;

b) The "savant" considered Research as an Art; his mean reason for doing research was his own intellectual and esthetic satisfaction. Almost none of the great scientists of the XVIIth century seems to have felt that they were beginning to hoard a treasure of knowledge which ought to become common property .

History tells us that two or three contemporaries , endowed perhaps with less genius and more sagacity, made it their business to organize the exchange of information between these somewhat reluctant Natural Philosophers. Father Mersenne, of Paris, is the best known of them. Later, these private mail officers were superseded by the foundation in Europe of the first national scientific associations. These were Academies whose transactions covered the complete realm of Natural Philosophy : the Royal Society (London), the French Académie des Sciences, the Academia del Cimento, the Academia dei Lincei, etc...; most of whose still exist to-day. Starting as clubs where scientific information was communicated and commented upon by word of mouth, the Academies soon came to publish their Transactions or Proceedings; these were the first primary scientific journals and it was the rules of exposition and the style practised in these Academies which fashioned the scientific paper and the preliminary publication as they still exist to-day.

Transactions and Proceedings of Academies have had a common feature : they covered the complete field of Exact and Natural Science, sometime extending further into human science and clinical medicine; by way of consequence, this coverage was necessarily loose and after an interval of less than a century, other learned national societies were founded - each of them having a more specialized interest, e.g. Physics, Chemistry, etc... These societies also publish Proceedings and, as publishers, behave very much in the same way as the Academies.

Because Academies and Societies were national in character and in fellowship (this does not mean that they had or have no foreign members !) and for want of a better denomination, we shall call National Journals the primary publications which they founded and are still responsible for.

We see that we can divide this class into two sub-categories :

Class I a/ Transactions of Academies, e.g. : Proceedings of the Royal Society (London) ;
Comptes Rendus de l'Académie des Sciences (Paris);
Proceedings of the National Academy of Science (Washington) .

Class I b/ Society Journals, e.g. : Proceedings of the Physical Society (London) ;
the Journal de Physique (Paris) ;
Journal of the American Chemical Society, etc..

Possibly because of the similarity of their historical development, many of these journals, if we may venture to consider them as living organisms, show the same or almost the same biological behaviour : most of them are highly respected and well known in the scientific world; most of them are proud of their history and tradition ; most of them serve a public of readers convinced that it is an honour to have a paper admitted to their pages; most of them, by way of consequence, never lacked copy; most of them, in spite of this, have shown themselves rather reluctant to expand and to found more specialized daughter journals .

It should be noted here that this description does not apply universally and that one important geographical exception seems to be the USA where the advent of scientific Societies, with their journals, came late, at the end of the XIXth century. Chapter III will show, for instance, how the American Institute of Physics in co-operation with the American Physical Society founded during the period 1920-1966 more than 12 increasingly specialized Journals designed to supplement the 1893 founded "Physical Review".

To-day, the founding of new journals of Class I has become a rare undertaking though the practice has not completely disappeared. When new National Societies are created with their journals, we note a growing tendency towards specialization. Comments upon this trend appear elsewhere in this report (1) .

- "Institution Journals" (class II)

This class includes journals published by Universities, Governmental Departments and Organizations, International Institutions, Industrial Concerns or Research Laboratories, etc... These apparently very diversified and numerous journals have one point in common which justifies putting them in the same class : they normally publish only papers and preliminary communications emanating from authors connected with the Concern or Institution publishing the Journal .

Apart from this common trait, they vary in almost everything else and certainly in scope, in level, in reputation. A few of them are considered by the scientific world at large as basic publications (and these, in almost all cases, are rather specialized); to give only one example, we shall cite the Bell System Technical Journal. In the same class but at the other end of the spectrum, we find publications maintained by Universities and publishing only papers written by their staff: in the national and international lists of periodicals, these publications generally appear quite numerous. Their importance and impact appear to be , however, much smaller than their numbers .

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(1) Cf. Chapter II, page 16 ; Chapter V, page 75

- "Publishers' Journals"(class III)

This class contains journals owned and managed by professional publishers and can be again divided into two sub-classes :

Class III a/ Old established, non specialized or loosely specialized journals : most journals in this category were founded during the XIXth century and sometimes even earlier (1); these all bear a close similarity to the Society Journals in Class I b , including a marked national character. Their geographical distribution is irregular : they are rare in many countries ; Germany is the home of many well known and respected journals in this category .

Class III b/ This class groups a different type of publishers' journals ; we shall call these : "International specialized journals". All the journals of this category are recent undertakings : almost none of them date back to 1940. All are specialized and their specialization seems somehow correlated with their age : the younger journals are also the more narrowly specialized. The circumstances of their establishment, the trends of their policy are closely similar . Each of these journals has an editorial board or panel of editors, each editor (honorary) being a well known specialist in the field and three or more nationalities being represented in this board or panel. The duties of the honorary editors are to find, in the country where they work,papers suitable for printing in the international specialized journal and often also to referee such papers. The actual management, the supervision of printing and distribution, and all the financial and business aspects remain the sole responsibility of the publisher.

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(1) The Philosophical Magazine was founded in 1798 .

International specialized journals, while increasing quickly in number, are published up to now by a limited number of professional publishers : it follows that each of these publishers may be responsible for quite a large number of international specialized journals. For instance, the monthly circular of a single publisher dated July 1967 gave a list of 70 journals of class IIIb, an issue of which had been dispatched during the month of May 1967. Five publishers with international connections have founded 198 new Journals during the period 1950 - 1967.

- Class IV, finally, holds periodicals which bring to the scientific world news, criticisms of books, accounts of the proceedings of recent scientific meetings, personal and necrological notices, etc... We might call them scientific newspapers. In supplement to their news sections, most of these scientific newspapers carry editorial articles, some of which may consider the ethical, political, social and human impact of the progress of science; most of these newspapers also have a section devoted to Letters to the Editor; indeed the practice of publishing short notes under this denomination probably originated with them .

Class IV, as the three other classes, must be divided into two sub-classes :

- To Class IVa, belong non specialized scientific newspapers which, as "Nature", "Science" aim at covering the whole spectrum of Science;
- In Class IVb, we find more specialized periodicals, the prototype of which is the well known and widely distributed Chemical and Engineering News.

All the periodicals of Class IV address themselves to the professional scientist, that is to say they do not attempt, by vulgarization, to reach a wider public. Vulgarized scientific and technical periodicals are also numerous and exist at several levels of popularity and technicity : the frontier between their field and the realm of scientific journals is not a sharply defined one .

The ICSU Abstracting Board has recently published two studies of important scientific journals belonging to Classes I, II and III and covering Physics and Chemistry (^{1}) . The reader will find in these documents a quantitative survey of a few hundred major scientific journals (legal status, description of Journal, rules of publication of papers, abstracts, indexes, advertisement, bibliographies, bulk published, price paid by a subscriber for 10,000 words of scientific papers, etc...) published in twenty countries .

Serials, Reports, Proceedings of Congresses

Apart from the periodical publications which we have just considered above, original scientific information may also be found in the pages of reports published at irregular intervals by learned institutions, governmental departments, etc... In some cases, these reports are numbered according to a common system and this group forms what we shall call a serial publication : the main difference between such a serial publication and a journal is that the serial does not bring forth issues at regular intervals. Serials of this kind play quite an important role in several countries among which the U.S.A. In this last country, to facilitate the acquisition and indexing of reports, serial or non serial, by libraries, monthly tables are now being published as a new periodical called "Government Research Reports".

We have already remarked, in the beginning of this Chapter, that the great value of Congresses and Symposiums was to be found in the opportunity they provide for personal contacts between fellow-specialists belonging to different groups and countries. However, the proceedings of such gatherings generally find their way into print; sometimes, proceedings will appear in a scientific journal belonging to Class II or III :

(^{1}) Some Characteristics of Primary Periodicals in the Domain of the Physical Sciences, 1966, ICSU Abstracting Board, 17 rue Mirabeau, Paris .
Some Characteristics of Primary Periodicals in the Domain of the Chemical Sciences, 1966, ICSU Abstracting Board, 17 rue Mirabeau, Paris .

this is, at present, a rather exceptional procedure. In most cases, the proceedings will appear in book form; we shall not examine further here this kind of publication : UNESCO has established a special Sub-Committee to examine the role played by congresses and symposiums in the scientific world and the report of this Sub-Committee should be available in the near future .

Further Processings of Scientific Information

To sum up, scientific information - born inside a laboratory - processed into a scientific paper or a preliminary publication, finds its way into a primary journal or, in some cases, a public report. Until the last years of the XIXth century, the procedure stopped there . However, by the 1890's, the flow of scientific papers published by the primary journals of the time was already too large for the confort of the University Professor or Research Scientist of the time : by 1896, the practice of Abstracting was well under way and Secondary Journals, devoted to the publication of abstracts, had been founded and were in regular operation. In the history of abstracting, three phases may be discerned:

a) During the first period, the abstractor behaved as the literary critic still does to-day : he gave a thorough analysis of the paper and also passed detailed judgment as to its value; no abstract was published of a supposedly "bad paper" (the critical abstract period) .

b) This point of view could not be held for a very long time : the widening spectrum of scientific specialities made it impossible to constitute a complete panel of senior scientists which would be capable of constructive criticism in each special field while being, at the same time, accomplished scholars for all the languages in which papers were published. A second period , therefore, was logically to open : that of the "informative abstract"; no judgment was now passed on the

the value of the paper, no criticism was expressed, but an attempt was made to procure an analysis so complete that there would be no need for the reader to refer to the original paper for further enlightenment. All abstracting journals and services have gone through this second phase and some of them still advocate the "informative abstract" (1).

c) However, the theory of informative abstracting raised strange questions. If it is really possible, in all cases, to make a completely informative abstract of a paper, why publish the paper at all ? (2). On the other hand, it may be argued that if it is possible to make a completely informative abstract shorter than the paper it sums up, this is proof that the paper in question was badly written and that a style manual is sorely needed. Finally, with the continued increase of the volume yearly published, the compilation of informative abstracts also was slowly becoming impossible .

d) We are now living in the third period of the history of Abstracting : that of the indicative abstract . The ambition of the abstracting journal is now only to list the paper , devote one or two sentences to say what it is about, one or two more to give an idea of the results obtained : from this indicative data, the reader of the abstracting journal must decide whether it is worth his time to hunt up the paper abstracted in the nearest library .

Because it represents a compromise and not a "perfect" solution, the advent of the indicative abstract took time. If the notion of indicative abstract is accepted, however, it becomes clear that the author of the paper himself, supervised if necessary by the editor of the journal, is quite able (3) to make the abstract himself : thus the practice of authors' abstracts began to generalize roughly at the same rate as the practice of indicative abstracting. It is easy to understand that, when and if it becomes universal, the compilation of the issues of an abstracting journal will be greatly simplified and speeded up.

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(1) This is mainly the case in the field of Chemical Abstracting.

(2) This is the starting point of some criticisms and proposals which will be examined further (see chapter V) .

(3) See Chapter V, page 76.

In recent years, the increased rate of growth of scientific primary literature resulted in an unconfortable bulk of the issues of the main abstracting journals : it began to seem that further processing would be necessary both for quick perusal by the scientific reader and for stocking, sorting and retrieval by automatic means : thus appeared various processing techniques which are still under development (lists of titles, systematic indexing, definition and use of key-words, etc..).

The manufacture, processing, distribution and retrieval of Primary Scientific Information is approximately summed up by the accompanying diagram n° 0/XVII, which will be used as a guide for the examination of criticisms and proposals to be found in Chapter V .

III - THE GROWTH OF PRIMARY JOURNALS AS SEEN THROUGH THE EVOLUTION OF A SAMPLE

Limits and Limitations

Any quantitative assessment in the field of scientific research literature is, strictly speaking, impossible because the limits within which the statement is supposed to apply and the definition of the terms in which the statement is formulated are both unclear : what is it that we call a Scientific Periodical ? What do we call Science ? Let us suppose that the World List of Scientific Periodicals, in its 1952 edition, contains 55,000 entries : a well-defined statement (1). However, let us open the book at random. On page 457, we find, amongst other entries beginning with the word "Journal" :

....

Journal of the National Society of Operative Printers and Assistants
Journal de la Navigation Fluviale et Maritime
Journal of the New England Waterwork Association
Journal of the New York International Garden Club
Journal of the Newcastle Farmers' Club
Journal des Nourrices

....

It will be clear to any scientist who reads this that we have no clear-cut, universally adopted definition of the term "Scientific Periodical", more, that such a definition probably does not exist and that, according to the interpretation given of the words scientific, technical, technological and professional, the number of periodicals included into the list will be subject to enormous variations.

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(1) For the sake of simplicity, we do not take here into account the fact that the work of reference mentioned lists all "scientific" periodicals which were in existence between 1920 and 1952, irrespective of whether or not they were still being published at the end of this period.

Again, the same indetermination affects the limits of what we may call "Science". Inside a single chapter of human knowledge, a complete gamut of periodicals may exist; but where are the frontiers of Science ? At what point in the spectrum of human endeavour do we leave the field denominated by UNESCO as that of "Exact and Natural Sciences" ? .

Sampling; Choice of Sample

It is for these reasons that we will try first to understand something of the growth of scientific Primary Journals through the examination of the evolution in time of an arbitrarily chosen group of journals or "sample" dealing only with one arbitrarily chosen and sufficiently well defined chapter of Science.

The limitations of this method of investigation must be clearly stated and understood : whatever care is taken in its composition and analysis, whatever precautions are applied to its determination, the properties of a sample are characteristic of the sample only. Generalizations may be suggested by these properties; they cannot be proved from the consideration of the sample alone.

The Chapter of Science chosen in the delimitation of our sample is Physics, the field of which is restricted to Pure and Applied Physics, exclusive of Engineering and of the application of Physics to other chapters of Science, for instance Astronomy. In the general direction of Chemistry, the limits of sampling remain a little vague and it is no definite delimitation to say that we include Chemical Physics, but not Physical Chemistry ...

Various reasons for the choice of Physics as a sampling domain may be put forward :

- the volume of original literature in Physics remains moderate;
- the number of Journals dealing with this section of Science is not too large (1) ;
- rules of publication, though far from unified, do not show large variations ;
- the practice of author's abstracts is a pretty general one ;

etc.. etc..

However, the fact that the field of Physics has already been the object of several important statistical studies and the fact that the present writer happens to be a physicist were certainly major motivations.

The composition of the chosen sample itself has been determined by several contingencies and logical arguments :

a) International sampling certainly appeared as highly desirable, provided that a fair balance could be maintained between the outputs of various countries taking a major part in Physical Research activities - a difficult condition, easier to formulate than to fulfill. However, the constitution and study of such an international sample appeared to be out of the question : the financial means and the time placed at the disposal of the present writer were much too small (2).

b) The constitution of a representative national sample was also not really possible : if a small country is to be chosen, the constitution of the sample will necessitate the analysis of Journals which are not solely devoted to Physics ; a majority of serial and even non-periodical publications may exist (e.g. Denmark); finally, the sample may be restricted to certain parts of the field chosen. If a large nation is the choice, it will be difficult to include in the sample all the literature which participates significantly in the national output. Therefore, the only sample which we may hope to select and analyse usefully will be a fraction of the national output of a large Nation

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(1) Cf. Chapter IV .

(2) For an attempt at international surveying through Secondary (Abstracting) Journals, see Chapter IV .

c) It follows then that the sample should come from a country which has been sufficiently active in the field of Physics (as defined above) during the complete interval of time taken into consideration.

d) The country chosen for sampling should have an economical and political history showing as few as possible discontinuities or accidents which may constitute disturbing factors in the assessment : the influence of such factors may later be exposed by comparing the behaviour of the sample with that of Journals produced in less fortunate countries .

No Nation in the world completely fits the conditions given above : the Nation which comes the closest is the United States of America. One should add that the U.S.A. Physics Primary Periodicals show to-day a degree of organization which seems to exist nowhere else in the world, with the exception of the U.S.S.R. We have therefore defined our sample as made up of 13 Journals, all belonging to the category of "Society Journals" according to our definitions of Chapter II, and dealing with the field of Physics as defined above and produced at present by the American Institute of Physics. Table I will give the constitution of this sample :

TABLE I

Journal	Began Publication	Devoted to
1 - The Physical Review	1893	Scientific papers (¹)
2 - Journal of the Optical Society of America	1917	- d° -
3 - Review of Modern Physics	1929	Review articles; letters ; discussions of current problems
4 - Journal of the Acoustical Society of America	1929	Scientific papers
5 - Review of Scientific Instruments	1930	Scientific papers; description of instruments
6 - Journal of Applied Physics	1931	From 1931 to 1937 : the title of this Journal was "Physics"
7 - Journal of Chemical Physics	1933	Scientific papers
8 - Physics of Fluids	1958	- d° -
9 - Physical Review Letters	1958	Advance communications and letters to the Editor
10 - Journal of Mathematical Physics	1960	Scientific papers
11 - Applied Optics	1962	Scientific papers and description of instruments (¹)
12 - Applied Physics Letters...	1962	Advance communications and letters to the Editor
13 - Journal of Vacuum Science and Technology	1964	Scientific and technical papers

(¹) Other material was discarded in the survey .

Unions Abstracting Board has determined the price paid, in 1964, for 10,000 words of original scientifc information, by a subscriber at the normal rate, for each of the 13 Journals of our sample; the computation was based on data given by the Journals themselves. Table II gives the results obtained (1).

TABLE II

Journal	Number of Pages published in 1964	Price paid per 10,000 words ($)
- Physical Review	13,642	0.0305
- Journal of Chem. Physics....	7,914	0.0501
- Journal of Applied Physics....	3,700	0.0775
- Journal Acoustical Soc. of America	2,525	0.138
- Review of Scientific Intrum...	2,366	0.130
- Physics of Fluids	2,000	0.149
- Journal Mathematical Physics..	1,805	0,139
- Applied Optics	1,774	0.0743
- Physical Rev. Letters	1,632	0.1532
- Journal Optical Society of America	1,600	0.250
- Reviews of Modern Physics..	1,110	0.236
- Applied Physics Letters	501	0.392

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(1) ICSU A.B., Some Characteristics of Primary Periodicals in the Domain of the Physical Sciences, Paris, France, 16 rue Mirabeau (Published with the Financial Assistance of UNESCO) - June 1966.

These results are also represented by Graph I , which is worth some attention. If we discard from the data the coordinates of points numbered 1 and 2 on this Graph, it will be seen that a smooth curve which will accommodate easily the rest of the data is a classical hyperbola of equation :

$$P = \frac{Ax + B}{Cx + D}$$

in which P is the price paid for 10,000 words in 1964 by the subscriber to a Journal of the sample and $\underline{x}$ the number of pages published in the same year, A, B, C and D being constants; this is just what we would expect to find if all the Journals were produced in a completely uniform way, on the same paper,by the same printer, in the same type, with the same ratio of hand-composition to monotype and linotype composition and of figures to printed type, etc.. ,provided the circulation of each Journal also varies proportionately to the number of pages printed (1) : the limit of P when the volume printed is small approximates

$$P_S = \frac{B}{D}$$

while the limiting price when the volume published is very large is

$$P_L = \frac{A}{C}$$

This is even true for the "Journal of Mathematical Physics", but two Journals represented in Graph I by points 1 and 2 do not follow this common behaviour ; they are : the Journal of the Optical Society of America, the coordinates of which fall a little over the common curve, and Applied Optics whose coordinates fall a lot lower than the common curve in this region. Applied Optics, it should be mentioned here, is the only Journal in the sample to carry advertisements.

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(1) The figure concerning the number of subscribers and/or the circulation were not available to the ICSU A.B. nor to the present writer.

Evolution of the Sample

We have followed the evolution of the sample from 1893 to 1966. During that time, the population in the sample has increased in a manner shown by Table III.

TABLE III

Time (years)	Number of Journals in the Sample
1893 - 1916	1 (Physical Review)
1917 - 1928	2 (J.O.S.A.)
1929	4 (Fev. Mod. Phys. J.A.S.A.)
1930	5 (Rev. Sc. Instr.)
1931 - 1932	6 (J. Ap. Phys.)
1933 - 1957	7 (J. Chem. Phys.)
1958 - 1960	9 (Phys. Fluids Phys. Red. Letters)
1960 - 1961	10 (Journ. Mod. Phys.)
1962 - 1963	12 (Ap. Optics Ap. Phys. Letters)
1964	13 (J. Vac. Sc. Tec.)

Surveying the Sample

Of course, the quasi-homogeneity mentioned earlier is a fairly recent achievement and it has been introduced gradually : many of the Journals have changed their format, their type, etc.. once or several times during their history; assessing the informative volume published was therefore a problem by itself; the procedure followed to solve this problem will now be described.

1°/ The total bulk of the sample investigated represented more than 500,000 pages of several formats. The collection of each Journal received a preliminary examination. In the course of this examination, the number of pages published each year was noted; from this number, indexes, tables, pages devoted to news, informations, isolated abstracts and anything except original scientific papers and their summary or abstract were discarded from the total. Changes in format were duly noted.

2°/ Another examination was then made volume by volume, in which the mean number of words per page was determined by sample counting of a certain number of pages. The number of pages sampled was not always the same because, from the abundance of equations and line drawings, it was sometimes difficult to find in a single volume more than 2 or 3 full pages. In the course of this second examination, it was found that, though 12 Journals have adopted a uniform format and a fixed type of character at some date or other, the number of words per page showed a tendency to increase with time through modification of the spacing. For instance, the sample counting for the Review of Scientific Instruments showed that, from 1933 to 1948, the mean number of words per page was close to 810. From 1949, this increased to 1,050 or thereabout without change of format and type; another example is that of Applied Optics which, in the course of its short life (1962-1967), has also practised some compression of the number of words per page .

It will be understood that we may have failed to detect all the variations in spacing, etc..; it is also clear that the "number of words per page" defined here is, by essençe, subject to random fluctuations so that all measurements using such a unit can be considered as fairly accurate if checking by independent observers does not show variations greater than ± 7,5 % .

With these reservations, the volume of published information in the sample was "measured" in words during a period of 74 years, very nearly 3/4 of a century. Table IV and Graphs IIa and IIb will show the results of these estimations :

TABLE IV

Year	Volume published, Words	Year	Volume published, Words	Year	Volume published, Words
1893	92.10^3	1918	425.10^3	1943	$2\,854.10^3$
1894	182.--	1919	418.--	1944	2 921.--
1895	184.--	1920	645.--	1945	3 225.--
1896	200.--	1921	660.--	1946	4 722.--
1897	214.--	1922	940.--	1947	5 826.--
1898	244.--	1923	1 087.--	1948	7 329.--
1899	244.--	1924	1 291.--	1949	9 237.--
1900	243.--	1925	1 324.--	1950	10 021.--
1901	293.--	1926	1 497.--	1951	10 893.--
1902	270.--	1927	1 147.--	1952	10 973.--
1903	345.--	1928	1 242.--	1953	13 754.--
1904	353.--	1929	1 885.--	1954	13 853.--
1905	313.--	1930	2 598.--	1955	15 108.--
1906	340.--	1931	3 084.--	1956	15 262.--
1907	402.--	1932	3 349.--	1957	15 743.--
1908	416.--	1933	3 974.--	1958	17 229.--
1909	398.--	1934	3 570.--	1959	18 848.--
1910	574.--	1935	3 595.--	1960	21 805.--
1911	461.--	1936	3 998.--	1961	24 020.--
1912	374.--	1937	4 523.--	1962	30 259.--
1913	381.--	1938	4 134.--	1963	32 575.--
1914	410.--	1939	4 762.--	1964	37 422.--
1915	401.--	1940	4 701.--	1965	41 907.--
1916	557.--	1941	4 520.--	1966	46 820.--
1917	603.--	1942	3 514.--		

Comments, general

The following brief comments are in order :

1°/ The period surveyed is a very significant one, not only in the expansion and history of American Research, but in the World's History of Physical Research .

2°/ Let us discard from our calculation the year 1893, in the course of which the only member of the sample then in existence, Physical Review, began publication. The ratio of the volume published in 1966 to that published in 1874 is 256 1/2. Because this ratio is so large, it has been necessary to draw part of Graph II twice, using different scales of ordinates.

3°/ The general graph may conveniently be divided into four parts, separated by easily discernible accidents occuring in the curve; these features are visible in spite of the presence everywhere of important "fluctuations" in the curve.

First Period, 1893 to 1914 - It is seen from Graph IIb that, though the increase in the informative volume published with time is quite irregular (note particularly the large fluctuations around 1910), the "best-fitting" smooth curve accommodating the results of the survey appears to be a straight line. The slope of the straight line which has been drawn at sight on Graph IIb is easily computed from this figure as circa $S_1 = 14,500$ words per year. If the mean increase during the period is computed from Table IV by calculating yearly differences and computing the arithmetical mean, we find a somewhat lower value of about $S'_1 = 12,000$ words per year (1).

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(1) It should be stressed here that no elaborated statistical calculations or interpretations were attempted : they would have been out of place in this first paper where we are concerned with general trends and behaviour of an evident kind. Also, irregularities in our data are rather large for statistical analysis to be really helpful .

First "accident", 1914 to 1918 - These are the four years of the First World War. During this period, the growth curve appears practically unaffected both in its random-looking yearly "fluctuations" and in the slope of the smoothed curve . However, at the close of this interval of time, it is very clear from Graph II that something has changed and that we are entering the

Second Period, 1919 to 1940 - Though "random" variations are larger than before, particularly during the second half of this period, it is clear that the "best-fitting smooth curve" is again not far from a straight line, though a punctilious observer might observe that the straight line drawn through this period on Graph II does not take into account the visible influence of a restraining influence contemporary with the economic depression of the 1924 - 1930. The slope of this line is :

$$S_2 = 200{,}000 \text{ words per year } \simeq 14\ S_1$$

Computation of the arithmetical mean increase from Table IV gave :

$$S'_2 = 167{,}100 \text{ words per year } \simeq 14\ S'_1$$

This fourteen-fold increase in growth after 1918 is ample justification of the surmise that the "anomaly' of 1914-1918 acted as a powerful accelerator in the production of printed original information by the Journals of our sample. It should also be noted that, just before the beginning of the second period, the number of Journals included in the sample was 2; it had become 7 in 1933, a number which remained constant till 1945 . The

Second "anomaly", 1940 to 1945 (Second World War) is noticeable both in its immediate and in its after effects. 1940 is still on the smoothed straight line of the second period, or close to it. Immediately after, there occurs a sharp dip in the curve; a minimal value occurs in 1943, when the level falls down to the ordinate reached in 1932, 11 years before.

Recovery does not really start till we reach the first half of 1945. The interpretation of all this is obvious. The after effects are seen immediately after 1945, when we enter the

Third Period, 1945 - 1957, which again shows a quasi-linear increase, rather well defined and with surprisingly little fluctuation. The slope of the straight line drawn through this period on Graph II is

$$S_3 = 951{,}000 \text{ words per year} \simeq 4.7\ S_2$$

while arithemetical computation gave :

$$S'_3 = 955{,}000 \text{ words per year} \simeq 5.7\ S'_2$$

The third "anomaly", 1957 to 1958, is not as conspicuous in Graph II as the two "anomalies" of 1914/18 and 1940/45 . This comes from the choice of our scale of ordinates. If we draw again Graph II from 1945 to 1966 with a reduced scale of ordinates, or if we just examine the figures listed in Table IV, we find that, after 1957, the rate of growth of the sample exhibits a sharp increase and that during the

Fourth Period, 1958 to 1966 (end of surveyed period), this rate of growth itself exhibits for the first time in 74 years a definite tendency to increase with time : in other words, the best fitting curve for this period would show a positive curvature. However, it has not been attempted to draw this curve (a period of 7 years duration is rather short). The computation of the mean rate of growth during this interval gave :

$$S'_4 = 3{,}523{,}000 \text{ words per year} \simeq 3.7\ S_3$$

In a later part of the present chapter, we shall find further proof of the existence and influence of what we have just called the "third anomaly". The reader will be able to remember that there occurred, at the end of 1957, an event of a politico-engineering character which had a very important influence on the general opinion of scientists, industrialists and politicians throughout the world : this was the launching of the first sputnik.

Influence of Fundamental Discoveries

So far, we have seen the very large influence on the growth of Primary Publications in the sample of major events which have a political, economical and industrial character . However, the sample under study contains much more "Pure" Physics than anything else : it should therefore be influenced by discoveries in fundamental Physics and not only by the growth of industrial potential, the advent of industrial electronics, etc.. etc.. A careful scrutiny of the curve will show however that, if such an influence exists, it is completely overshadowed by what we have called the "random" fluctuations of the output. To take only a few examples, there is nothing to show, in Graphs IIa and IIb, the advent of relativity (1905) nor the birth of wave mechanics in 1924, nor the beginning of the electron theory of semiconductors in 1928. In Nuclear Physics, there is nothing in our curves coincident with any major discovery or with other fundamental advances in Particle Physics... From that point of view, the sample seems to behave as if the yearly output was independent of the upheavals which might follow a major advent in fundamental theory, so that what occurs after such a change would seem to be a shift in the general orientation of papers but not a change in their volume.

Exponential Growth in the Sample ?

In our comments, so far, we have looked at the growth curve in a rather near-sighted way : most of the preceding remarks, and especially the existence of four periods showing linear increase, make sense on a decennial scale. Let us now change the perspective by looking at the curve from a point of view distant enough to smooth out most of the "fluctuations" present; on a secular scale, we may smooth out our curve in a way which Graph III shows to be almost legitimate, if we neglect the trifling exception of World War II. For reasons already stated, the smooth curve of Graph III has not been computed but only drawn at sight.

Table V gives the ordinates y of the smooth curve as a function of time, taking the year 1896 as the origin of the time scale. A third column gives log y and Graph IV will show the variation with time of log y . If the smooth curve drawn in Graph III was an exponential, or nearly an exponential, Graph IV should exhibit a straight line. Actually (we must remember that the ordinates are logarithms), there is quite a large departure from linearity : our smooth curve is a parabola of some kind but not an exponential. A correct analysis of this fact would necessitate a knowledge of the growth curve representing the number of Research people actually at work as a function of time, data which the present writer does not possess (1) . However, one may venture to say that there is nothing very surprising in the preceding result : biological growth is an exponential phenomenon only when it occurs in a dimensionally unlimited medium affording unlimited food supply and in the absence of limiting factors such as disease and predators .

After this examination of the behaviour in time of the sample taken as a whole, let us now examine the behaviour of some of the more important Journals included in it .

The Case of Physical Review

From 1893 to 1916, this was the only Journal in the sample. Graph V shows what occurred after this : till 1932 and in spite of the creation of four new Journals, Physical Review published 50 % or more of the total yearly volume of information in the sample. After 1932, this percentage of importance decreased slowly to a value of approximately 36 % at the beginning of the Second World War. Since "the Physical Review" is the main Journal in the sample for Nuclear Physics Information, the deep decrease of its relative importance during World War II is easily explaines; we see that in 1945 the Physical Review is responsible only for some 15 % of the informative volume published that year in the sample. After this, of course, recovery sets in rapidly and since 1948 the "importance ratio" of Physical Review oscillates between 30 and 46 % : to sum up, Physical Review remains the leading Journal of the sample and its own behaviour in time must have a very visible impact on the growth curve of the entire sample which we have just examined. Graph VI shows that this is indeed the case; we recognize, in the growth curve of Physical Review, the four "periods" and the three "anomalies" which we had already discerned in the complete sample growth curve. Indeed, Graph VI is especially interesting during the years 1954 to 1960 : we see that, from 1945 to 1955, the growth of Physical Review is almost exactly rectilinear; it then stops abruptly; in 1957, we even find a decrease; on and after this date, it appears that a restraining factor and an accelerating influence are simultaneously at work : 1957 is a minimum, 1958 is a maximum, and after 1959 which shows again a decrease, an unhampered accelerated growth sets in, the slope becoming even larger after 1962 .

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(1) ... and which cannot even be completely defined, since the sample chosen does not contain the whole output of information in Physics produced in the U.S.A.

Journals with Similar Behaviour in Time

The Journal of Applied Physics also has a most interesting growth curve (though short: it was founded in 1931). The Second World War did not affect it as severely as it did Physical Review. After 1945, we find a quick quasi-linear growth succeeded, from 1951 to 1957, by a period where a restraining influence is visibly at work; this influence gives way after 1957 and we revert, till 1966, to a quick quasi-linear growth with one faltering in 1961.

The Journal of Chemical Physics has the most spectacular growth curve of the whole sample. The 1957 accident is as easily visible on Graph VIII as it was in Graphs VI and VII.

Journals with Different Growth Curves

The three growth curves which we have just considered exhibit evident similarities so that we can consider them as members of one family. Other Journals of the sample have, however, growth curves of a very different kind. Amongst these, we first consider the second oldest Journal in the sample, the Journal of the Optical Society of America. Graph IV shows the growth curve of JOSA from 1918 to 1966. One can see that this growth curve may be divided into two main periods :

a) During the interval 1918 to 1940, there is a gradual building up (from fundation to 1924) followed by a longer period of depression, so that the integral mean level practically coincides with the ordinate of the curve for 1939 ;

b) From 1939 to 1966, in spite of quasi-random fluctuations, the volume published increases practically linearly with time. A very remarkable fact is that the Second World War of 1940 to 1945 does not correspond to any important accident of this growth curve .

The Journal of the Acoustical Society of America, founded in 1929, has a very remarkable growth curve, as Graph X shows : in spite of a pronounced dip during the years 1940 to 1945, we can say that the curve has only one "period" and, when smoothed, is evidently parabolic in character at any time during this single period. The Journal of the Acoustical Society of America is the only Journal of the sample to behave in this manner.

Finally, Graph XI represents the growth curves of the well known Reviews of Modern Physics. The only comment which will be made about this curve is that, discounting usual quasi-random fluctuations, the volume of information published per year remains approximately constant till 1949/1950; from 1950 to 1966, fluctuations in the volume published become extremely large; through these, we can distinguish a definite upward trend.

In the course of this very rough analysis, we have purposedly, as far as possible, refrained from any subjective interpretation of the facts arising from the visible graphic behaviour of our sample and we have tried to state causes of these visible effects only when such causes appreared self-evident and completely non-controversial. We have not attempted either to find out whether all the fluctuations noted in the growth curves were really of a "random" character or whether financial, or other sociological parameters, may have had some influence : this could be attempted only by persons having a very serious knowledge of the history of the sample and of the sponsors of the various Journals.

We shall conclude this very uncomplete analysis with two remarks :

a) The specialization of each Journal has a marked influence on its absolute rate of growth M , but not on the relative rate of growth as Table VI shows in spite of the fact that its computation leaves a wide margin of error; the ratio between M and the 1966 output decreases only slowly with M : this shows again the modern homogeneity of the sample.

TABLE VI

Order of Magnitude of the Mean Increase
of Volume Published During the Period
1945 - 1966

By	Mean Increase M Words per Year :	Relative Increase : M/1966 output
- Physical Review	710,000	0.044
- Journal of Chemical Physics ..	420,000	0.043
- Journal of Applied Physics	205,000	0.040
- Journal of the Acoustical Society of America	110,000	0.0395
- Review of Scientific Instruments	60,000	0.034
- Journal of the Optical Society of America	50,000	0.029
- Review of Modern Physics	41,000	not computed

b) The study of the sample leads on the whole to conclusions which are highly complementary to the American Institute of Physics, and to the policy it has followed in the matter of Primary Publications during the last 20 years .

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Two European Examples

At the beginning of the present chapter, it was expressly stated that the study of a representative international sample had seemed to the present writer out of the question within the time and means at his disposal. However, the following two examples will show how far the American sample we have just studied may be from representing the general behaviour of the world's main Primary "Society" Journals :

1°/ The collection of the Proceedings of the Physical Society (London) was scanned throughout the period 1934 to 1966. The results of this analysis are shown by Graph XII ; throughout the period, the format and the type of characters employed remain constant, though modifications in spacing and number of lines may have intervened : Graph XII does not take this possibility into consideration. One can see that the Second World War has had upon this British Journal precisely the same effect as on the American sample and that recovery had already begun by 1945. However, between 1950 and 1964, a powerful restraining influence must have been active since the yearly volume of information published, during this period, is actually found to decrease slightly with time. Growth starts again during the years 1964/67, roughly at the same speed as during the period 1944/1948. Between the volumes of information published in 1966 and in 1934, the ratio is approximately 3.4, small when compared with the rate of increase in our American sample.

2°/ Le Journal de Physique et Le Radium is a French publication of long standing. We analysed the period 1928 to 1966; here important changes in format and in type occurred and have been allowed for; during a number of years within this period, le Journal de Physique et Le Radium divided its pages between the publication of original scientific papers and the abstracting of papers appearing in other Journals : this has also been allowed for and Graph XIII gives the result of this survey.

During the period 1939/1941, a severe decrease occurs : the ratio 1939/1941 is about 3.7 . Recovery starts as early as 1942; after a slight check during the interval 1946/1948, the growth curve becomes quite steep. However, from 1953 to 1965, oscillations in the output of information printed become so large as to deprive of its meaning any attempt at smoothing. Between the volumes of information published in the years 1963 and 1941, the ratio is 14.7 .

IV - THE EVOLUTION OF ORIGINAL SCIENTIFIC LITERATURE AS SEEN THROUGH SOME OF THE MAJOR ABSTRACTING PERIODICALS

In the field of Physics and of its applications, there exists several major abstracting periodicals. "Physikalische Berichte", produced in Braunschweig, publishes abstracts in the German language. "Physics Abstracts", printed and produced in London, is the main abstracting Journal for Physics in the English language. The "Bulletin Signalétique" (C.N.R.S.) and the "Referativnyi Zhurnal" respectively publish abstracts in French and in Russian (1).

These four Journals have, in recent times, been the object of several important analytical studies; the results of two of these studies have already been published. These are :

1°/ "The Journal Literature of Physics" (a comprehensive study based on Physics abstracts - 1961 issues), by Stella Keenan and Pauline Atherton, New York, American Institute of Physics, 1964;

2°/ "World Literature in Physics as Seen Through Bulletin Signalétique (1964 issues)", Mrs J. Poyen, Paris, International Council of Scientific Unions (Abstracting Board).

Most of the data gathered in the following pages have been taken from the pages of these two important documents.

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(1) It should be remembered that these two abstracting Journals are covering the whole scientific field and not only that of Physics .

The Growth Curve of "Physics Abstracts"

"Physics Abstracts" is the first part (formerly Section A) of "Science Abstracts, produced by the Institution of Electrical Engineers., the second part being called "Electrical Engineering Abstracts" (formerly Section B) and since January 1st, 1967, "Electrical Engineering and Electronic Abstracts". Table I which has kindly been supplied to the present writer by the Editors of "Science Abstracts" records the number of abstracts published each year by the two parts of "Science Abstracts" :

TABLE I

Year	A (Phys.Abst.)	B (Elect.Eng. Abst.)	Year	A (Phys.Abst.)	B (Elect.Eng. Abst.)
1898	1,423		1933	5,491	5,491
1899	2,000		1934	5,269	2,992
1900	2,525		1935	5,251	3,080
1901	2,506		1936	5,716	3,525
1902	2,362		1937	5,494	3,252
1903	1,532	1,069	1938	5,081	3,622
1904	2,339	2,965	1939	4,705	2,811
1905	2,308	1,710	1940	3,230	2,155
1906	2,171	1,481	1941	2,737	1,818
1907	2,132	1,474	1942	3,152	1,672
1908	2,070	1,367	1943	2,968	2,600
1909	2,161	1,191	1944	2,688	2,197
1910	1,910	1,104	1945	3,148	2,744
1911	1,749	1,281	1946	3,273	2,977
1912	1,916	1,356	1947	3,765	3,233
1913	2,022	1,294	1948	4,068	3,119
1914	2,041	1,208	1949	7,500	4,151
1915	1,789	1,152	1950	9,198	4,366
1916	1,397	949	1951	9,908	4,650
1917	1,385	864	1952	9,292	5,132
1918	1,283	886	1953	8,830	5,144
1919	1,583	942	1954	11,693	5,402
1920	1,669	1,117	1955	10,160	5,403
1921	2,012	1,197	1956	9,165	4,661
1922	2,477	1,248	1957	9,998	6,451
1923	2,542	1,574	1958	9,201	6,434
1924	3,160	1,650	1959	14,016	7,718
1925	2,808	1,811	1960	21,407	8,537
1926	2,996	1,831	1961	21,167	7,110
1927	3,238	1,985	1962	24,336	15,038
1928	3,355	2,110	1963	26,000	16,300
1929	3,687	2,250	1964	31,000	16,177
1930	4,165	2,537	1965	34,000	19,500
1931	4,365	2,607	1966	38,000	21,332
1932	5,364	2,926			

From 1898 to 1902 inclusive, "Science Abstracts" was published as a single monthly periodical. Graphs XIV and XV, which respectively record the growth of the two sections accordingly start with 1903.

In the course of 63 years of publication, during the most productive and varied period in the world's history of Science, it is clear that the point of view of the Editors and the relative importance given, in the contents of the Journal, to the various chapters of Physics, must have changed several times : we shall not try to trace this evolution in the comments which follow :

1°/ "Physics Abstracts" is mainly concerned with Pure and Applied Physics, as defined already in Chapter III of the present Report (1), while Section B is mainly Electrical and Electronic Engineering in its classical form. It is seen that the two growth curves are very similar in their general trend.

2°/ The curves of Graphs XIV and XV also show marked similarities with the growth curve of the sample which was studied in Chapter III (2) : we have again here four definite periods separated by three accidents; this is so evident that we shall reduce our comments to a bare minimum :

First Period : 1903 - 1914 - After a short maximum occurring in 1904 (it is probably the consequence of an arrear of abstracts carried over when partition occurred), the number of abstracts published per year remains practically constant ("Physics Abstracts") or exhibits a slight tendency to decrease (Section B).

The first accident (First World War 1914-1918) confirms this tendency to decrease in the two curves.

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(1) cf. Chapter III : Sampling, choice of Sample.

(2) cf. Graphs IIa and B.

Second Period : 1918 - 1940 - This period shows, in the two curves, a linear increase up to 1936. It is probable that the troubled state of Europe between 1937 and 1940 is the main explanation of the decrease recorded by the two curves during this latter time interval.

After the second accident, the Third Period is clearly indicated as beginning in 1945 and ending in 1958 in the case of "Physics Abstracts", and in 1961 in the case of "Electrical Engineering Abstracts" : the third accident occurs later in Graph XV than in Graph II.

The similarity of the growth curve of "Science Abstracts" and the growth curve of the A I P sample is too great to be explained by coincidence : we shall have therefore to determine whether the similarity is due to the major influence of American literature in "Physics Abstracts" or whether it is a reflection of a general trend of the world's literature in Physics of this period.

For the present time, we duly note a third accident in our growth curves, followed by a fourth period characterized by a greatly enhanced rate of growth.

3°/ The relative rate of increase in "Physics Abstracts" is much smaller than that of our A I P sample. It will be remembered that the ratio of the volume published by the sample in 1966 to that published in 1874 exceeded 250. The ratio of the volumes of information published respectively in the years 1966 and 1905 works out at 16.5 for "Physics Abstracts" and 12.5 for "Electrical Engineering Abstracts".

Let us try to understand more completely what this means. For this purpose only, let us suppose that the world's literature in Physics has been at any time from 1904 to 1966 solely made up of papers having a uniform length of 6 pages, each page containing 960 words; under these assumptions, the bulk of information abstracted by "Science Abstracts" Section A in 1904 works out approximately at 13.5 million words; in the same year, the output of our sample was smaller than 360,000 words; the ratio between these two figures is about 2.7 %.

In 1966, "Physics Abstracts" has abstracted 38,000 papers. With the same assumption, this corresponds to 219 million words. In the same year, the A I P sample output came close to 47 million words, which is more than 21.4% of the whole. While this numerical value depends on the rather stupid hypothesis which we have made, it is clear that the relative importance of American Scientific Literature analysed in "Physics Abstracts" must have grown very considerably during the period 1904/1966 and that the ratio 21.4/2.7   8 is a quite interesting rough measurement of this trend. We shall presently analyse a little more precisely the place of American Literature in Abstracting Journals during the recent years.

Coverage Supplied by Major Abstracting Journals

It should be fairly clear to the reader by now that the number of abstracts published yearly by "Physics Abstracts" must always have been quite small compared with the total number of papers published by Primary Journals during the same time; there is even a suggestion (the speeding up of the growth curve occurred later in "Science Abstracts" than in the A I P sample) that its coverage may decrease with time. To investigage this further, we shall compare the 1964 issues of "Physics Abstracts" and of the "Bulletin Signalétique" (Division of Physics) :

TABLE II

	Physics Abstracts (1)	Bulletin Signalétique (1)	Ratio
Abstracts of Papers published in Primary Journals	23,652	circa 76,000	2.65
Number of Journals scanned	420	2 797	6.66

(1) Data procured through the courtesy of "Bulletin Signalétique" . Physics Abstracts, ICSU Abstracting Board; the assessing of the limits of the "Physics Division" in "Bulletin Signalétique" leaves of course a margin of incertitude in the data figuring in the third column of Table II.

However vague the limits of the "Physics Division" in the study of the "Bulletin Signalétique", the ratio of the number of abstracts published for Physics in 1964 by the two Abstracting Journals, which works out as 2.65 in favour of "Bulletin Signalétique", cannot be justified uniquely by this laxity of evaluation. Moreover, while "Physics Abstracts" was able to extract a little more than 28,000 abstracts from 420 Journals, the "Bulletin Signalétique" had to scan almost 3,000 Journals to get its 76,000 abstracts. The only possible explanation of the results listed in Table II is quite simple : there is not such thing as complete coverage of a chapter of Science by an abstracting Journal; discrimination of some sort is always active and the limits set by this in "Physics Abstracts" are narrower than for the "Bulletin Signalétique".

Core Journals

There is no Physicist in the world and probably no scientific Librarian who could give from memory 200 names out of the 400 Primary Journals in the Physics Abstracts list, not to mention the 2,800 Journals scanned for Physics by "Bulletin Signalétique". It is therefore quite important to study systematically the contributions of these many Physics Journals to the Abstracting periodicals.

The 1964 study of the "Bulletin Signalétique" already cited has done that and Table III will give us the result of this analysis :

TABLE III

"Bulletin Signalétique", Physics, 1964 issues

Journals Scanned	Number of Abstracts Obtained from each Journal
7	From 1 001 to 3 031
14	" 501 " 1 000
42	" 201 " 500
114	" 101 " 200
176	" 51 " 100
354	" 21 " 50
671	" 6 " 20
1 419	" 1 " 5

We see now that 1,419 Journals, that is to say 50.7 % of the total of the Journals scanned gave only each 1 to 5 articles which the Editor of the "Bulletin Signalétique" thought fit to abstract in the "Physics Section". Further analysis reveals that the output for these 1,419 Journals was 2,966 abstracts, that is to say 3.6 % of the total : if we were Physicists talking about medium precision physical measurements, we would consider these 3.6 % as a quite permissible error.

Continuing the analysis on these lines, we further find the following results :

TABLE IV

1964 Survey of Bulletin Signalétique (Physics)

22	Journals provided	25 %	of total number of abstracts
116	- d° -	50 %	- d° -
197	- d° -	60 %	- d° -
309	- d° -	70 %	- d° -
489	- d° -	80 %	- d° -
838	- d° -	90 %	- d° -

We begin to get the impression of a hard core of solid physical literature which the Editor of the Abstracting Journal considers must be analysed or abstracted from cover to cover; this is surrounded by softer and softer layers of a more or less original literature of diminishing influence and importance . Of course, as the preceding Tables have shown, the percentage of significance of these layers varies without any discontinuity : so does the price of abstracting, which must rise steeply indeed with the percentage of coverage which we decide should be achieved .

We might remember at this stage that at least 80 % of the articles and papers published in Primary Physics Journals throughout the world now carry authors' abstracts of good quality, so that the price of the abstracting may be more influenced by the number of Journals scanned than by the number of abstracts published. If this is true, let us remember that, if we want to increase our coverage from 50 % to 80 %, the number of Journals to scan is multiplied by more than 4.5 ; let us remember also that when we are talking here of relative coverage, we suppose that, in 1964, the 2,797 Journals scanned by "Bulletin Signalétique" provided this Abstracting Journal with complete coverage in Physics : this is of course nonsense .

Table III and IV concern only "Bulletin Signalétique". What do we know about "core" and "soft" Primary Journals in Physics Abstracts ? Table V, compiled from the data of the S. Keenan and P. Atherton survey of the 1961 issues of "Physics Abstracts" will answer very suggestively this question:

TABLE V

Physics Abstracts, 1961 Issues

Main Division of Index	Journals Scanned	
	to get 50% of the number of abstracts printed	to get 100% of the number of abstracts printed
Astrophysics........	13	115
Physics, general	4	26
Mathem. Physics	9	99
Mechanics	6	59
Physics of Fluids,etc.	13	154
Acoustics, etc.	2	52
Optics	8	102
Heat and Thermodynamics	10	103
Electricity and Magnetism	14	182
Nuclear Physics	6	141
Elementary Particles .	4	97
Cosmic Rays	8	50
Atomic and Molec. Physics	6	107
Solid State Physics..	11	184
Elect.properties of Solids	8	118
Optic.properties of Solids	8	74

The present writer would like to emphasize the importance of this notion of core Journals : it is one thing to organize a World Information System providing, say, a probability of 0.8 of furnishing to a customer a full quota of relevant information and it is quite another thing to increase this probability to 0.95 or to 0.99. Finally, even if such a perfect World Information System existed, we could never prove that we have reached such probabilities of complete information, or the administration of such a proof would in itself be quite costly.

The reader now understands that there can be no economically feasible "perfect" or "near perfect" System of Scientific Information and Communication based on Scientific Journals. Indeed, the probability that this holds true for any System of Scientific Information and Communication is strongly suggested (1). The fact that many Scientists, having a mathematical and physical training which has made them familiar with very general notions of "noise " and "distortion", insist upon perfection in this field is a little difficult to understand .

Dominant Nations

Let us now consider another problem : in the output of papers abstracted in a period of time by an Abstracting Journal , what is the share of each of the nations of the world ?

A fairly precise answer to this question is to be found in the 1961 survey of "Physics Abstracts" and the 1964 survey of the "Bulletin Signalétique" :

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(1) Cf. Chapter V .

TABLE VI

Nation of Origin	Physics Abstracts 1961		Bulletin Signalétique 1964	
	Number of abstracts	% of total	Number of abstracts	% of total
U.S.A.	6 316	31.14	30 949	37.6
U.S.S.R. ..	3 317	16.37	12 309	15.0
Great-Britain	2 729	13.45	7 934	9.6
Japan	1 560	7.69	2 965	3.6
France	1 268	6.32	5 859	7.1
Germany ...	1 240	6.11	8 222	10.0
Netherlands .	1 043	5.23	2 850	3.5
Italy	675	3.25	2 021	2.5
India	352	1.72	not extracted	not extracted
Poland	309	1.50	1 030	1.3
Sweden	not extracted	not extracted	990	1.2

We see that there is pretty good agreement between the two Abstracting Journals regarding the importance given by them to American and Russian literature and also that there is some justification for the rather wild calculation made on page 48 about the variation with time of the relative importance of the A I P sample. They diverge however on the subject of the importance of British-produced literature and this divergence is important enough to give the third place in the Physics Abstracts list to the U.K. while this rank is awarded, in the French periodical, to Germany. An evil-minded person might immediately look at the assessment of French publications which he could think would be much greater in "Bulletin Signalétique" than in "Physics Abstracts" : remarkably enough, he would be disappointed. Upon two other points, there is practically complete agreement between the two Journals, despite the fact that their analysises were not made in the same year :

a) The literature in Physics produced in U.S.A. and in the U.S.S.R. represent about 50 % of the number of abstracts published ("Physics Abstracts": 48.5 % ; "Bulletin Signalétique" : 52.6 %) .

b) Seven nations together produce more than 86 % of the total number of abstracts published ("Physics Abstracts": 86.3 % ; "Bulletin Signalétique": 86.4 %).

The importance of this geographical repartition should be borne in mind by any person interested in the improvement of the present state of things.

Dominant Languages

Table VII, extracted from the study of "Physics Abstracts" (1961 issues), will give a rough idea of the repartition of languages in the literature abstracted by this Journal.

TABLE VII

Major Languages of Papers Abstracted
("Physics Abstracts" - 1961)

Division	Number of papers abstracted	Original in			
		English	Russian	French	German
Astrophysics......	906	700	61	-	-
Physics, general..	76	57	7	-	-
Mathem. Physics ..	696	492	60	95	-
Mechanics	163	117	25	-	-
Phys. of Fluids ..	1 206	823	149	112	83
Acoustics, etc. ...	409	250	81	-	61
Optics	558	322	61	49	101
Heat, etc.	506	361	74	-	-
Elect. and Magnetism	2 342	1 456	428	191	188
Nuclear Physics....	2 902	2 057	370	251	139
Elementary particles	1 238	919	204	-	-
Cosmic Rays	224	77	28	-	-
Atom. and mol. Physics	1 339	1 015	113	-	-
Solid state Physics	3 059	1 936	694	134	185
Electr.prop. of solids	1 342	770	366	-	-
Opt.prop.of solids	667	377	135	-	-
Total :...	17 633	11 729 (66.5 %)	2 856 (16.2 %)	-	-

The Russian language percentage is in very good agreement with the results already listed in Table VI : the use of the Russian language is practically confined to papers printed in the U.S.S.R. The situation is very different for the Enflish language whose dominance in Table VII is very striking indeed. Of course, "Physics Abstracts" is an English publication but the consideration of "Bulletin Signalétique" leads to similar conclusions : a much more complete analysis of the distribution of languages is to be found in the ICSU A.B. survey of the 1964 issues of the "Bulletin Signalétique"; the section giving the distribution of the languages of the original articles according to the country of origin is of special interest. For instance, the reader will not ve surprised to learn that 94.5 % of the papers abstracted by "Bulletin Signalétique" and produced in the Netherlands were written in English but he may not know that this percentage for Italy is close to 71 %, close to 75 % for Poland and close to 43 % for Czeschoslovakia, to drop to circa 37 % for Japan, 17 % for Germany and a little less than 4 % for France .

Relative Importance of Non-periodical Original Literature

For both Journals and both surveys, it is found that the number of abstracts coming from papers published in scientific Journals, that is to say in periodical publications, is somewhere between 80 and 82 %. Non-periodical literature (i.e. reports, monographs, proceedings of congresses, etc..) represents therefore 18 to 20 % of the total number of papers abstracted.

Other Fields of Science : Chemistry

Time and facilities were both lacking to extend the preceding survey to other chapters of Science. However, from documents published recently by the management of "Chemical Abstracts", a growth curve may be drawn for this major abstracting Journal and useful or suggestive comparisons with the field of Physical Abstracting may be made (1).

Table VIII records the number of abstracts published each year by "Chemical Abstracts"; the abstracts concerning patents have been discarded, as we are not concerned in this report with patent literature .

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(1) See "C.A.S. to-day", a pamphlet published in 1967 by the Chemical Abstract Service, American Chemical Society, Columbus, Ohio, U.S.A.

TABLE VIII

Year	Number of Abstracts	Year	Number of Abstracts
1907	7,975	1937	44,032
1908	10,835	1938	45,917
1909	11,455	1939	45,414
1910	13,006	1940	40,624
1911	15,892	1941	35,588
1912	15,740	1942	30,479
1913	19,025	1943	30,523
1914	16,468	1944	30,440
1915	12,200	1945	22,824
1916	10,519	1946	29,943
1917	10,921	1947	30,461
1918	9,283	1948	35,867
1919	10,957	1949	40,612
1920	13,619	1950	47,496
1921	15,211	1951	50,657
1922	18,070	1952	56,419
1923	19,507	1953	61,273
1924	20,523	1954	67,606
1925	20,951	1955	74,664
1926	23,103	1956	78,009
1927	25,037	1957	84,205
1928	28,153	1958	95,736
1929	29,082	1959	98,680
1930	32,731	1960	104,484
1931	32,278	1961	118,337
1932	37,403	1962	140,168
1933	36,139	1963	141,016
1934	38,371	1964	161,489
1935	42,593	1965	165,770
1936	41,927	1966	181,715

Graph XVI has been drawn from the data given by table VIII. The similarities with the growth curves of Physical Abstracts and of our AIP sample are too obvious to need much comments. In all these growth curves, in spite of local accidents which must have occurred at different times and with different causes and orientations (1), we find the same four periods of growth. In graph XVI, the growth during periods 1 (1907-1914), 2 (1918-1938) and 3 (1945 - 1961) appear to be close to linearity. The fourth period of enhanced growth begins for Chemical Abstracts in 1961, as compared with 1957 for the AIP curve and 1959 for the Physics Abstracts graph .

Chemical Abstracts began publication in 1907 only. If we compare the number of papers abstracted in 1966 and in 1908 respectively, we find :

$$R = \frac{181,715}{10,835} \simeq 18$$

Compare with the 16.5 fold increase in Physics Abstracts between 1905 and 1966 : the agreement of two R which admittedly both have a non-negligible random component is really rather striking. However, the growth curve of Chemical Abstracts in the second and third periods has much larger (and constant) derivatives than in the case for Physics Abstracts. During the time interval 1907-1966 (inclusive), Physics Abstracts and Chemical Abstracts respectively published 436,093 and 3,619,152 abstracts : the ratio is close to 8.30 ; during the year 1966, the same Journals respectively published 38,000 and 181,175 abstracts : this second ratio is about 4.77 ; by that time, both periodicals had been thoroughly reorganized . Probably in the scientific literature of to-day, one may find 5 or 6 papers (or preliminary publications) dealing with Chemistry against one dealing with the field of Physics - but this is guessing, and guessing about something which is very far from clearly defined .

However, the authors of "C.AS. to-day" also guess that in the complete realm of Exact and Natural Sciences, one paper out of six or seven is chemical or contains chemical information. They also state that 30 % of the World's Scientific

(Primary) Journals contain information of Chemical or Chemical Engineering significance (the field of Applied and Engineering Chemistry is covered by Chem. Abs.). Such a statement supposes that we have either an exact definition of Primary Science (pure and applied) Journals, or else a catalogue. If we accept it, since the Chem. Abs. staff examined in 1966 about 12,000 journals, we might deduce from this that the total number of scientifically valuable Journals according to our elusive definition or contained in our non-existent catalogue is circa 40,000. This evaluation may be compared with the 59,961 entries found in the last (1960) edition of the World's List of Scientific Periodicals, a publication using, as we have seen, a rather generous definition of the locution "Scientific Periodicals".

Also quite similar in the fields of Physics and that of Chemistry is the productivity of the Journals scanned. Compare Table IX with Tables IV and V .

TABLE IX

Journals productivity according to Chem.Abs.

Number of Journals Scanned in One Year to Produce ...	... the Following Given Percentage of the Total Number of Abstracts Published
10	10 %
50	26 %
100	36 %
500	63 %
1,000	74 %
2,500	90 %
5,000	96 %
12,000	100 %

The notions of "core" and "other" Journals introduced à propos of Physical Literature crops up again with the same quantitative significance. To sum up, the very rough and uncomplete data contained in this paragraph confirms surprisingly well the conclusions arrived at in the case of Physical Literature .

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V - TRENDS_ CRITICISMS, PROPOSALS

Dissatisfaction with the present state of affairs has been growing (not only in scientific circles), as did the bulk of Primary Scientific Information published yearly. Most complaints, however, have been framed in rather general terms; constructive criticism has been rare and so have been concrete and sharply defined proposals for improvement. As time went on, a spontaneous evolution of the situation has taken place, as a consequence of the efforts of the persons and institutions at present responsible for the processing of primary scientific information. Trends , criticisms and proposals form an ensemble which it is difficult to dissect and analyse. In attempting to do so, we shall first be guided by diagram n° 0/XVII which is repeated at the beginning of the present chapter.

- A -

Area I : Production of Primary Scientific Information

1°/ There seems to be no dissent about the fact that Scientific Papers and Preliminary Publications are proper forms of literature for announcing and describing original scientific information (1)

2°/ We have dealt already with the growth in bulk of primary publications; this seems due partly to the fact that papers (and preliminary publications) increase in number with time and partly to the fact that their average length also increases with time, although perhaps at a slower rate. We have very little data about the latter increase. However, from figures kindly communicated to the author by the American Institute of Physics, one can deduce that the average length of a paper published by the Physical Review remained in the vicinity of 3,000 words during the period 1946-1953, that around 1956 it was over 4,000 words, reached 6,000 words in 1958/60 and is about 7,000 words to-day. This trend has received very little official attention till now. It would be important to know whether it is general or limited to some countries or to some chapters of Science. There is no indication that the number of papers and preliminary publications increases much faster than the number of responsible scientists at work on research (1).

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(1) See, however, page 80 of this chapter .

3°/ Criticisms have been voiced not only regarding the style and other literary aspects of the composition of Scientific Papers but also to stress the need of observing simple rules of Ethics in their drafting. To meet these criticisms and improve the situation, a working Committee convened by UNESCO and on which were represented the International Council of Scientific Unions (ICSU), the ICSU Abstracting Board, the International Standardizing Organisation, the International Federation of Documentation, etc.. , studied and proposed in 195 a "Code of Good Practice for Scientific Publications" which continued and supplemented the Guide for the Preparation of Abstracts (Synopses), published several years before. This document was prepared in two versions, French and English; when circulated by the Division of Exact and Natural Sciences of UNESCO, it met with sufficient approval to render the preparation of a Spanish and of a German version necessary. The USSR Academy of Sciences' Institute of Scientific Information prepared and distributes a version in the Russian language. Some tens of thousand copies of this "Code of Good Practice" have been distributed by UNESCO in the course of the last three years. The fact that one member (out of six) of our Sub-Committee had no knowledge of it in June 1967, though he held an important responsible position in the world of Scientific Publishing is significant of communication difficulties which will be briefly commented upon below.

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(1) Compare with paragraph on duplication (page 73 of present chapter).

All the other members of the Committee agreed upon the main principles and recommendations set forth in the "Code of Good Practice for Scientific Publications"; this agreement does not mean that the present text should be considered as final, but rather as a good starting point to arrive at a universal ethical document, which would be supplemented by Style Manuals which might slightly differ from language to language and from division to division of Science.

4°/ It has often been stated that the publication of simple rules of Ethics are unnecessary, since no responsible research scientist ignores them already. To this trend of thought, we may refer the reluctance of one of the members of our Committee regarding the use of the word "Code" (1). However, papers that do not follow the "Code" rules, or even which do not fall under the definition given are not uncommon. The conflicting necessities of

- a) regular publishing in order to get renewal of research grants and to legitimately ensure continuation of the authors' careers ,
- b) preserving national or industrial interests and property

probably constitute a sufficient explanation for their publication. Examples of such papers, with due criticism of them should be useful here. For obvious reasons of fairness, it has seemed better to withdraw them from this report.

5°/ Other criticisms concerning frequent duplication in Primary Scientific Publication have also been made; though the responsibility of the authority releasing the papers may have something to do with duplication, the matter will be more conveniently dealt with under area II .

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(1) Another suggested title for the same document is : "Guide for the Preparation of Scientific Papers for Publication" .

Area II : Primary Publication

1°/ "There are too many journals in this area". This blunt, often met with critism, deserves careful examination . From Chapter IV, we learn that the main Abstracting Journals in the field of Physics and Chemistry find as a rule 75 % of the papers they list or abstract in only 10 % of the Journals that they scan - and none of them claims to be able to scan all the Journals they know of and which may carry valuable and relevant material at one time or another... This suggests that the major part of the volume printed by 90 % of Journals is of little value from the Primary Information point of view. Since the 10 % "core" journals are not all abstracted from cover to cover, we have here an indication that a reorganisation of the scientific press tending to establish a family of "core Journals" numbering perhaps 400 in the field of Physics, 1,200 for Chemistry and 2,400 (?) for Biology and carrying 85 % of the current primary scientific information is not unthinkable.

2°/ It must be immediately declared that any extension of the preceding remarks in the direction of increasing the 85 % mentioned to 100% is not practical and probably will never be, whatever system of communication is used.

3°/ A conceivable reform is not necessarily a possible one. Let us examine the present state of the Scientific Press from a financial and business point of view. For the sake of argument, let us say that we have to deal with 40,000 journals, that the average subscription rate is $ 15 and the average number of subscribers at that rate is 800 . The turnover of the Scientific Press "business" works out then at circa $ 480,000,000. Now, possibly one half of this total number is made up of journals not only independent but which have no connection with other members of the Scientific Press: we arrive here at the conclusion that, while the Scientific Press of to-day, considered in bulk, is a large industrial business, an isolated Scientific Journal appears as a small and vulnerable enterprise.

4°/ Add to this the fact that an important percentage of the total number of Journals are actually losing money and subsist because of grants which are conceded them for reasons derived from national interest and/or prestige considerations : we see how it is comparatively easy to found a new Journal and at the same time a difficult enterprise to maintain this Journal at an acceptable scientific-cum-financial level.

5°/The remarks made in paragraph 4 are not applicable to Journals published in the USSR and countries governed according to the same rules of political economy. Leaving these countries out of the argument, since the Scientific Press is free and since nobody suggests attempting a reformation on compulsory lines (this would be totally unrealistic), there remains only one practical way of improvement, a way which has been used many times in other fields of industrial or business enterprise : grouping. However, the formation of groups in business is often retarded or even stopped by the existence of frontiers, political, economical and ideological ; it may be thought that such is the case for the formation of groups in the Scientific Press.

6°/ Since the first Scientific Information Conference it is known that, amongst other things, something must be done about Primary Journals publication, but this statement has never been transformed into specific recommendations. If there is some truth in the preceding considerations, it would seem that a possible way to get out of this dead-lock would be to organize at the International level co-operation between National groups of two kinds :

a) National Committees appointed either by Governments or by learned National Institutions ;

b) National Associations of Editors of Scientific Journals.

UNESCO, in association with the scientific non-governmental organizations (ICSU, etc..), would be the obvious sponsor of such a long-range move. Is International Cooperation strong enough at present to initiate such a project and pursue its development with the necessary activity and enthusiasm ?

The answer to this question is evidently not within the scope of this paper. At present, the U.S.A. seems to be the only country where the formation of important groups has already occurred (e.g. the Journals governed by the American Institute of Physics or grouped round the American Chemical Society).

7°/ We now come to more localized, or more concrete criticisms. The delay occurring between the arrival of a proposed paper upon the Editor's desk and its appearance in an issue of the Journal is said to be too long and to show a tendency to increase. Let us try to see what these delays are. The following table was compiled from recent issues of Journals picked up at random from a reading-room shelves; though limited to one discipline and to 8 journals, it is quite representative .

TABLE X

Journal	Issue	Date of Paper Submission	Delay
- the Physical Review	April 1967	August 1966	9 months
- Zhurnal Technecheskoï Physiki	October 1966	October 1965	12 "
- Proceedings Physical Society (London)	May 1967	(Nov. 1966 (Dec. 1966	6 " 5 "
- Journal de Physique (Paris)	March/April 1967	October 1966	7 "
- Physica Status Solidi (Berlin)	March 1967	(Aug.15,1966 (Nov.23,1966	6 1/2 " 3 1/2 "
- Japanese Journal of Applied Physics	May 1967	(Jan.18,1967 (Dec. 8,1966	4 1/2 " 5 1/2 "
- Physical Review Letters ..	June 5,1967	(28 April 1967 (24 April 1967 (5 May 1967	circa 6 weeks
- Physics Letters	June 12,1967	(10 May 1967 (17 May 1967	circa 5 weeks

Most of the Journals which figure in this table use the referee system and it must be remembered that the referee will quite often suggest modifications and improvements : the paper then returns to the author. The Proceedings of the Physical Society (London) print the date of resubmission of the paper in its revised form; using this data, we find that the average delay of publication for most papers figuring in the May 1967 issue of the Proceedings was circa 4 months. Of course, it often happens that the issue may be delivered to the Post Office later than the date it bears on its cover .

Whatever judgment the reader may form from his own experience about publication delays, the following remarks remain adequate :

a) the referee system is rarely criticized. The existence of a set of rules of good practice, and the generalization of style manuals should help both referee and author to save time ;

b) most abstracting journals are now produced from typescript prepared according to fixed rules, with or without optical justification, by the offset process. The extension of this practice to some of the Primary Journals would be a matter for investigation. Quite a few "Letters to the Editor" Journals are already using this system, which certainly saves much time ;

c) to the delay in publication, which is critized by users, must be added the delay in distribution which, in the case of surface mail, may become quite important. Between Continent and Continent, this delay may be reduced to a few days by using air mail. But, in the present state of things, air mail charges for printed matter are often prohibitive. For instance, where the Y fare for a passenger is F.F. 1,369,(1) the air mail rate for 75 kg of printed paper in one single bundle is already F.F. 1,050.(2) In the face of this result, the present writer did not try to compute what the amount paid would be for 150 single copies each weighing 0.5 kg (about 1 lb) mailed in separate envelopes. Reduction of these rates in favour of scientific journals would be again a matter for International Cooperation.

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(1) $ 279.-

(2) $ 214.-

d) It should be underlined that in the younger circles of Scientific Research, complaints about delay in publication are numerous and emphatic. In some particularly active fields (molecular biology, microgenetics for instance), recrimination is loud and quasi-universal : this has been the starting point of several revolutionary proposals, with consequences which will be examined below (1).

8°/ Another criticism frequently met with concerns duplication : this occurs too often, clogs the information and documentation channels and ought to be curbed. This apparently simple statement must be analysed with due caution as the comments of three Members of the Committee have shown :

a) The announcement of new scientific information should be the object of one preliminary publication and/or one fully informative scientific paper : this is a matter of what has been called "Good Practice". However, the multiplicity of languages used may explain and excuse, in the case of important data, a multiplicity of Primary Publications. Theoretically, duplication of this type is supposed not to occur since the Editors of many important Journals insist on publishing only original information .

b) Duplication in Primary Publications, however, is encouraged by the present situation of a part of the Scientific Press ; roughly speaking and from this point of view, we may divide the Scientific Journals into two classes : Journals which never lack copy and indeed regularly turn down some of the material offered to them for publication, and Journals whose Editors must canvass for copy in order to keep the yearly output of the Journal at a sufficient level : the author is then sollicited to publish variations of his original paper. Congresses and symposiums may have a similar influence.

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(1) See subdivision C of the present Chapter .

c) Leaving aside rules of Good Practice already commented upon, is it possible to take practical measures to keep objectionable duplication at a reasonably low level ? The only move which may have this influence consists in the generalization of the system of page charges, already in operation in the case of a limited number of Journals, most of them located in the U.S.A. Briefly, the system of page charges arises from the principle that a research project cannot be considered as terminated as long as its results have not been published. From this system, follows the proposition that since publication is the last act of a research project, its cost should be paid for out of the funds allocated to the said project; therefore, the Journals publishing original scientific papers and preliminary publications should not be subsidized by grants, etc... : for each paper published, the Journal should receive a certain amount of money coming from the research fund and proportional to the volume to be published.

This is quite a new departure, the advent of which has produced in the field of scientific publishing some enthusiasm and some opposition. The Ad-Hoc Committee is far from unanimous agreement about the page charge system; all its Members recognize that it may be a deterrent to publication and to the present trend of longer papers but, while one Member does not like, for ethical reasons, to link page charges with a move for the reduction of publication, another Member remarks that the system will keep authors from publishing their results several times only when it is generally adopted; this Member believes, however, that the general use of the page charge system would bring considerable difficulties : how could it be checked that a private publisher makes proper use of the money he receives from public funds through page charges ? Also there is some doubt whether the general adoption of the page charge system will not put review journals in an economically unfavourable situation relative to Primary Journals.

d) However, the general feeling of the Committee is that it will be important to watch the development of the system of page charges and to try to assess the consequences of its generalization .

9°/ It has been suggested that "National Journals" - most of which which are not specialized and therefore will publish papers on subjects spreading across large chapters of Science (Physics, Chemistry, Biology, etc..) - should disappear and be replaced by a series of International Speicalized Journals. The feeling of several Members of the Committee about this has been already described in Area II, paragraph 6.

10°/ The continued existence of non-periodical publications containing original scientific information has also been criticized. Even when such publications are numbered consecutively, the fact that they appear at irregular intervals, that their price will vary from one issue to another, that in most cases there is no possibility of subscribing to the series, etc..., makes it difficult for foreign libraries to get all of them before they get out of print . There appears to be no consciousness of this difficulty in the highly developed countries which are the home of most non-periodical publications.

Area III : On the Fringe of Further Processing

Area III of diagram 0/XVII appears to be out of the scope of the present report. However, there are many things that Primary Scientific Journals could do and which would help to economize money and time needed by the abstracting and indexing processes .

1°/ We have seen that though some abstracting journals (especially in the field of Chemistry) continue to insist on the publication of informative abstracts, the practice of publication of indicative abstracts is generally gaining ground. Now there appears to be no objection whatever to the proposed rule that no paper should appear in a primary scientific journal unless accompanied by an indicative abstract produced by the author and supervised by the editor - in fact, such is the case to-day for more than 75 % of original literature abstracted in the field of Physics. A Guide for the preparation of this type of abstracts has been drafted more than 10 years ago and is freely distributed by UNESCO. A persuasive campaign would do a great deal towards persuading authors of papers of the importance of producing their own abstracts.

If the publication of satisfactory authors' abstracts becomes general, the economy made in time and in expenses by most abstracting Journals will be so evident that no further comments are needed. In several countries which have abstracting Journals, it is a duty for a research worker who receives a grant or a salary to do certain quantity of abstracting every year : this compulsory labour system would also become unnecessary .

2°/The advent of automation and of computers in the field of scientific information has created a very important need for simple standardization procedures.

Let us suppose that an abstracting journal or an indexing service wants to store (in printed pages or in electronic memories) the title of a paper , the name of its authors and possibly the authors' abstract. In order to do this, the whole material to store must be read and re-written in the proper way and this work is to-day human work, that is to say it is expensive, tedious and must be checked for mistakes. If no standardization occurs, this expensive human intervention will remain necessary as long as we do not have at our disposal the very complex character-recognition equipment able to read a large variety of present day publishing (type or character, size, horizontal spacing, vertical spacing, format, etc..).

Standardization of size of pages, of the type of character and spacing used for the title, authors' names, and eventually for the abstract, is possible and even, for a respectable number of Journals, quite easy. If such standardization was to occur, it would also be comparatively easy to build the equipment which would transfer automatically the block of information consisting of title, authors' names, and abstracts from the pages of the preliminary journal to the storage system of the abstracting or indexing office. Such an equipment would not even be unduly expensive. Unhappily, and in spite of the great advantages to be derived from the establishment of simple standardization rules, the situation of the Scientific Press regarding this matter appears at present almost hopeless. It is true that there is a move towards unification of the page size of Primary Scientific Journals . Against this credit, the debit account of journal standardization appears heavy. International groups and organisations have discussed for more than 14 years the possibility of establishing standard rules for the abbreviation of the names of scientific periodicals in bibliographical citations. At the time of writing the present report, two different systems of abbreviation have been standardized, one by the International Standardization Organization, the other by the American Standards Association which is the american member of I.S.O. In a bibliographical citation, volume, page, year of publication must be given : it has not been possible to get an international agreement on the order in which these three indications should be printed. Here again, international action aiming to instruct the world of scientific publishing of the importance of standardization might have important beneficial consequences.

The trends and proposals examined in the preceding pages all concern the present system of scientific information production and publication. Other proposals have been made which are not concerned with the reformation of the several stages of the present system. The first family of these, while accepting the present system, urges that it be completed by some new organization. The second family advocates a complete revolution .

- B -

The proposals of the first family center round the creation of a World Center or Network of Scientific Information. In some of them, the World Center (or Network) would act as a sort of clearing-house system; in others, it would also create an effective system of providing current awareness (1) (this introduces a certain kinship with the revolutionary proposals examined below under C) .

Since UNESCO has appointed a special working group on the feasibility of a World Wide Science Information system and is considering the formation on a joint ICSU/ UNESCO Committee on the same matter, we shall consider that the study of such proposals is outside the scope of the present report.

However, the reader may be interested to learn that the first proposal for a World Information Center seems to have been made more than 71 years ago : in the second week of July 1896, an International Conference, organized by the Royal Society, to consider the preparation and publication of an international catalogue of scientific literature, opened its proceedings. A week later, the conference "had laid a sound basis for the greatest scientific bibliography ever contemplated" (2). Some of the resolutions which were then accepted unanimously read as follows :

> " That it is desirable to compile and publish by means of some international organisation a complete catalogue of scientific literature, arranged according both to subject matter and to authors' names".

....

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(1) In some countries, and for some divisions of Science, lists of titles are already being issued, often as a supplementary advance service organized by an Abstracting Journal.

(2) cf. "Nature", Vol. 54, pages 248 and 272. The writer is indebted to Profs. H. EBERT and WEIDEMANN for this remarkable reference.

"That in preparing such a catalogue regard shall, in the first instance, be had to the requirements of scientific investigators, to the end that these may, by means of the catalogue, find out most easily what has been published concerning any particular subject of inquiry".

....

"That any country which shall declare its willingness to undertake the task shall be entrusted with the duty of collecting, provisionally classifying, and transmitting to the central Bureau, in accordance with rules laid down by the International Council, all the entries belonging to the scientific literature of that country".

....

"That in indexing according to subject matter regard shall be had, not only to the title (of a paper or book), but also to the nature of the contents".

....

"That the catalogue shall comprise all published original contributions to the branches of science hereinafter mentioned, whether appearing in periodicals or in the publications of Societies, or as independent pamphlets, memoirs, or books".

....

"That January 1, 1900, be fixed as the date of the beginning of the catalogue".

....

The full text of the thirty five resolutions is very illuminating indeed. Time has been lacking to look up in the literature the possible follow-up to this 1896 Conference .

- C -

In a second family of proposals, the present system of Information publication and distribution is either partly disregarded or completely ignored; the reason for this is quite fundamental in character and proceeds from the state of mind which has already been alluded to in this report (1) : during the time interval spent in preparing a paper, getting permission to publish, having the paper examined by a referee, printing and distributing, research has been going on, money spent, experiments made which would have been influenced by an advance knowledge. Even in the hypothetical case where such delays would be compressed to an absolute minimum, say three months in toto, this would still be too long, it is argued, in many cases : for those chapters of Science which are in explosive development and where research teams are at the same time numerous, very scattered and little organized it would be important to know almost day by day what "the others" are doing or even what they are trying to do. No matter whether the information is correct or not, has or has not been checked : this is the recipient's affair. We understand that this intellectual attitude leads to the notion of advance information which, as we see, is something quite different from the content of a Paper or even of a Preliminary Publication.

In some such proposals, Journal publication might continue, the service of advance information being established more or less independently. In other schemes, the publication of Journals would stop and two new systems of information processing would be established, working either independently or in co-operation : the "Advance Information Exchange" just mentioned and a system for the distribution of checked and refereed information in which Papers would still be written, but not printed; they would be stored in some way and only the corresponding author's abstract would be published and distributed. From these abstracts, the reader would judge whether or not he wants to read the complete text of a given paper, in which case he would apply to the organism where the paper in question has been stored and which would print or copy the paper by some process or other; of course, the user would have to pay for the copy he has ordered .

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(1) Cf. this Chapter, page 73, paragraph d).

It will be seen that schemes of this kind tend to substitute to the present state of things, which is based on the principle of public distribution and dissemination of Scientific Information a one or two degrees system of group or person to person communication. This, if examined from the point of view of pure logic, is rather fascinating : it is quite true that highly specialized and/or advance information may be of first rate value when it is released only to a very limited number of persons scattered all over the world and that such information should reach them in time to influence their own work and prevent (perhaps) useless experiments and therefore waste of public money. Accepting this, we abandon the idea of the public-and-mass information system and we revert to the XVIIth century practice of Mersenne's Exchange Bureau for Newsletters. If we are to organize this with modern means, we at once see that such a system of communication, in its principle, has much in common with a private telephone network; unhappily, we have no telephone book and, though some countries are busy compiling a classified Directory of Research Scientists, there is little hope that we will ever get a sufficiently up-to-date register to avoid leaving out deserving customers. We also see that, in solutions of this kind, detailed advance information will only be available to a certain group of people : one must be "in" to participate in the Service .

An advance information scheme has been operating in the USA from 1961 to 1966 (Information Exchange Groups) . It started when, during a Symposium, a small group of Molecular Biologists decided to create an advance information bulletin made up from very short letters written by each of them and describing "without delay" progress, experiments and results .

Supported later by the National Institute of Health, the experience started on March 2nd, 1961, within a very limited circle. In 1964, five other groups had been created and were taking part in the Advance Information Exchange System. In May 1965, the number of scientists taking part was several hundreds. In December 1966, this number was 3,588 and by this date the yearly cost of the enterprise grown to this size was estimated at circa \$ 400,000. On February 1st, 1967, the system suspended operation. It has been alleged (1) that, if it had gone on for two years more, the Information Exchange would have had to serve 14,000 members divided into 200 groups exchanging some 30,000,000 letters and costing about \$ 100,000,000. This would not have covered the whole of Biological Research. It is interesting to remember at this stage that, when trying to get at an order of magnitude for the turnover of the present-day primary scientific journals (for all chapters of Science), we arrived at an (admittedly very dubious) estimate of \$ 480,000,000.

Let us now abandon the logical and even the scientific angles to look at the "problem" of getting Scientific Information to the man who wants it, at the proper time, from a business point of view : in a public dissemination solution, the price of a copy of the "newspaper" goes down when the number of its readers goes up. In selected groups or person to person communication, even when the price of the unit of communication remains constant, the total expense is bound to be either almost proportional to the number of participants (and this would be an ideal case) or to this number n at the power α , with α larger than 1 . To return to the telephone simile, a local call is very cheap; nevertheless, the telephone system as a whole is a colossal undertaking. Turning back to the newspaper simile for our present Journal system, we must own that it is redundant - even if the process is cheap - to distribute tons of printed paper to thousands of persons, each of whom are likely to read perhaps one twentyeth of the literature he thus receives: this, also is the common practice of the ordinary daily Press .

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(1) M. ALLAIN-REGNAULT - "Le Monde", June 15th, 1967, page 13 (in French) .

VI - CONCLUSIONS

I - No mechanical or automated process may improve the quality of a scientific text .

II - The general opinion of the scientific world seems to be that original papers and preliminary publications are proper forms for the first processing of scientific information. A set of definitions and of simple professional ethical rules concerning the drafting of original papers and of preliminary publications would be useful .

III - It is possible that the amount spent each year on printing and distributing primary scientific information is insufficient and should be increased. It is probable that, in the absence of such an increase, better results could still be obtained by introducing in the present system various reforms tending to ameliorate efficiency and speed.

IV - The number of Primary Journals at present published may be too large. Their geographical distribution, their repartition in the various fields of Science, the degree of their specialization may not be satisfactory.

V - The introduction of a degree of standardization in the production of primary scientific Journals (format - characters and spacing in the printing of titles, names of authors and abstracts - bibliographical citations and abbreviations) could result in a substantial reduction both of cost and of delay of Abstracting, Indexing and generally further processing operations.

VI - To reach the improvements considered as possible in the preceding conclusions, some degree of organization of the Scientific Press on the National or Regional Scale (national committees, associations of Editors) would be highly desirable; international co-operation between these regional or national groups would be necessary. This last enterprise could be one of the duties of a future World Information Center or Network.

VII - Publication delays in Scientific Journals could be shortened by the use of multiplication methods other than the classical lead-characters-and-printing-system. However, no technical improvement within sight will cut down the sum of preparation, publication and distribution delays to an absolute minimum small enough to accommodate the distribution of advance information .

VIII- The distribution of advance information may be needed in some swift growing domains of research. This may be achieved, in the case of groups of small size, by the establishment of closed systems involving person to person or group to person communication. Extrapolation of such systems to large groups and/or to numerous individuals seems to raise questions of feasibility and of expenses which have not yet been satisfactorily and systematically investigated.

IX - The same remark seems to apply to Scientific Information Systems in which papers deposited in a central office (instead of being published) are copied upon individual request. The serious assessment of the possibilities of the systems considered in paragraphs VII and VIII could be one of the duties of a future World Information Center.

X - A few Philosophers and Political Economists have remarked that the present rapid extension both in breadth and in depth of Science may find some day a limitation in the impossibility for a single mind or even a group of persons to grasp the whole of one sufficiently large and self-sufficient of its chapters. The growing difficulties met with in the processing and distribution of scientific information may be considered merely as one particular aspect of this more general problem .

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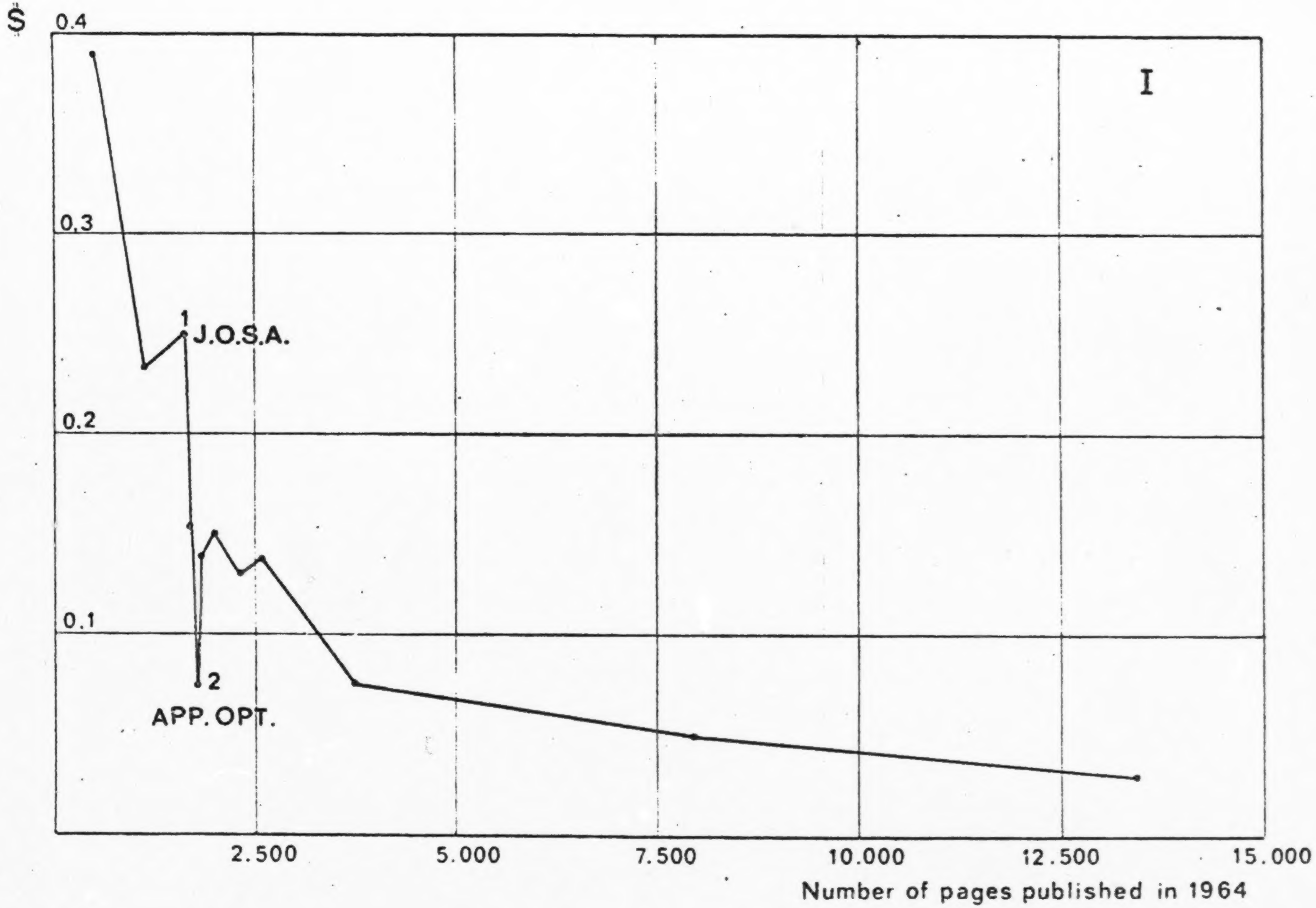
S
0.4
0.3
0.2
0.1
I
1 J.O.S.A.
2
APP. OPT.
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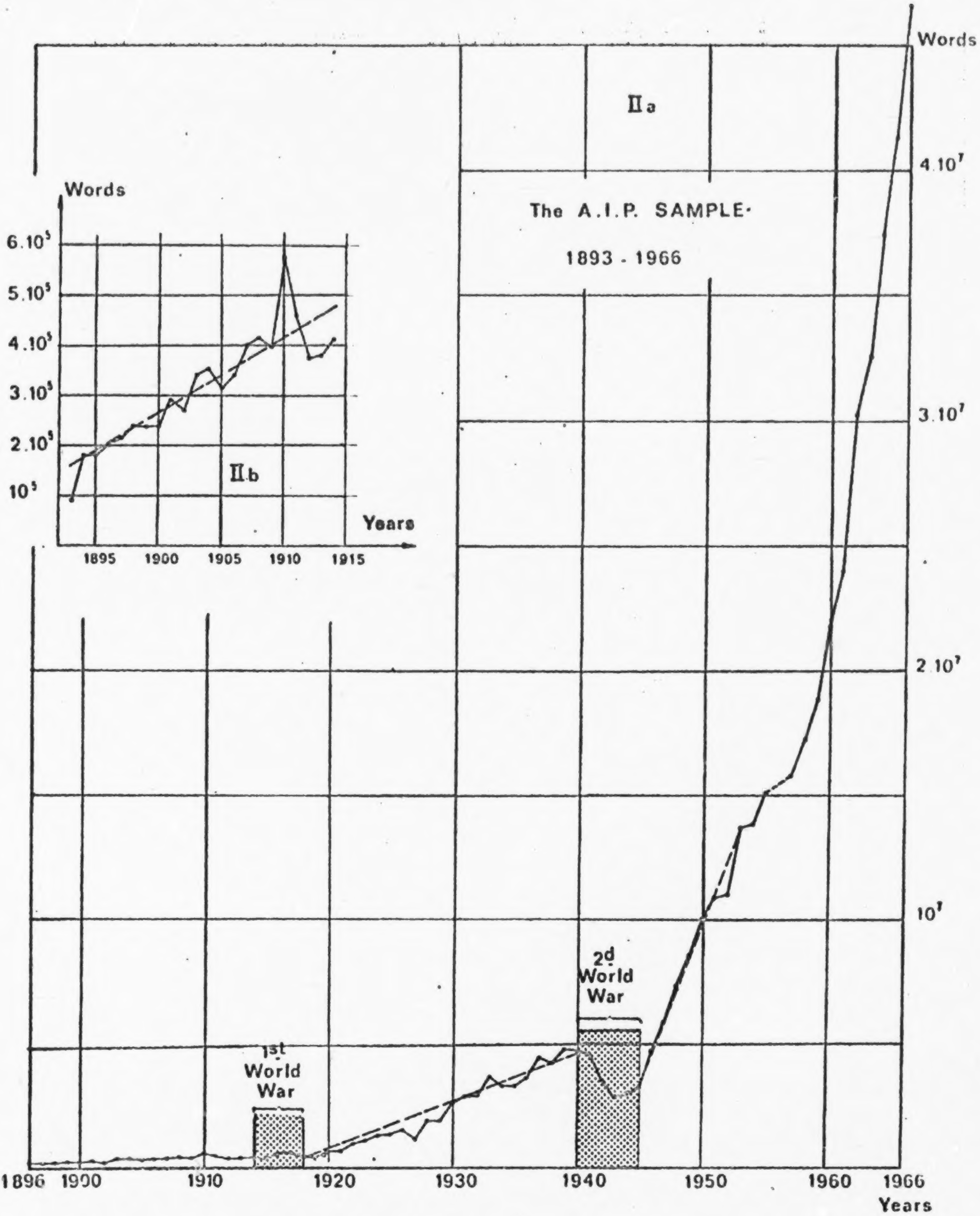
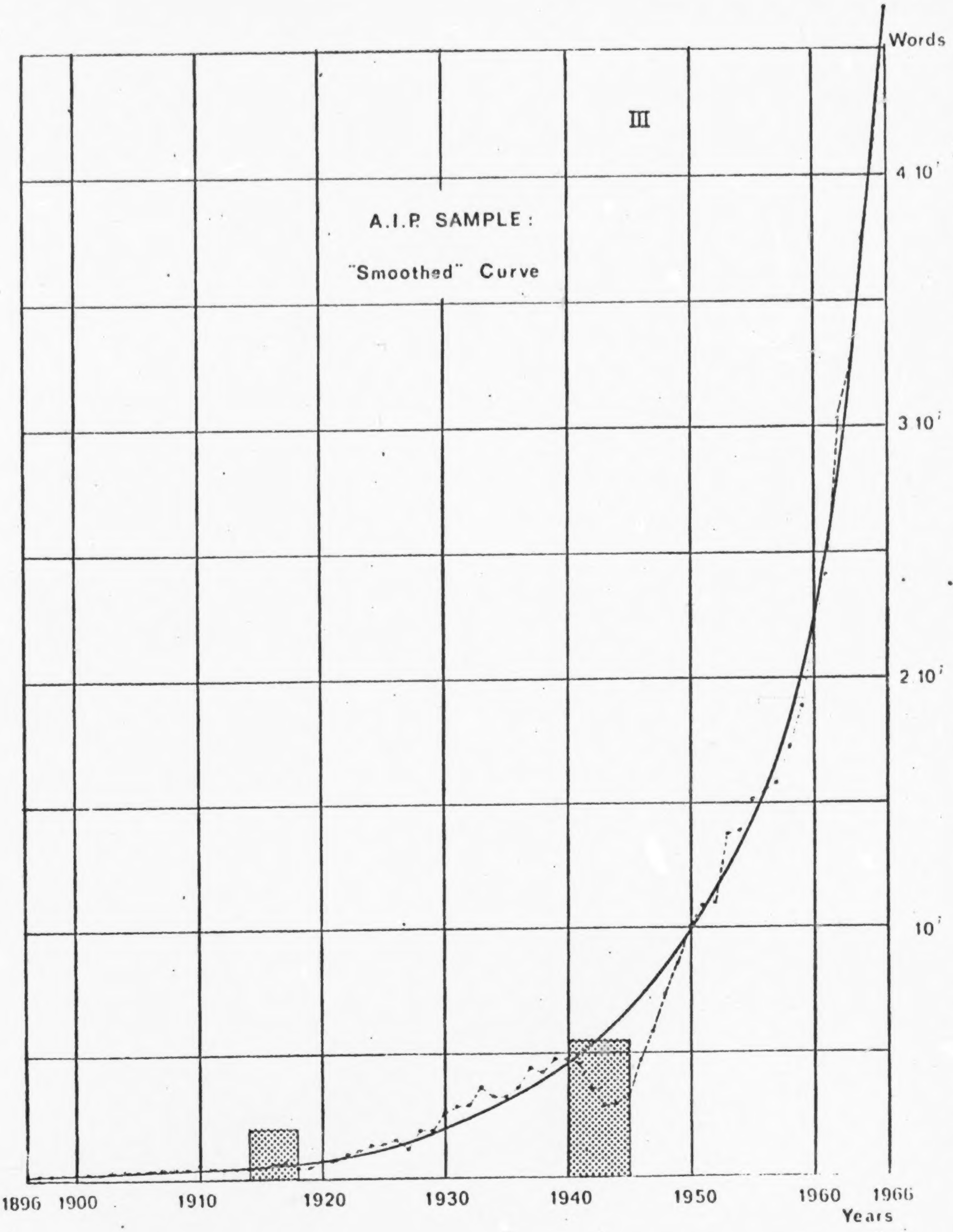
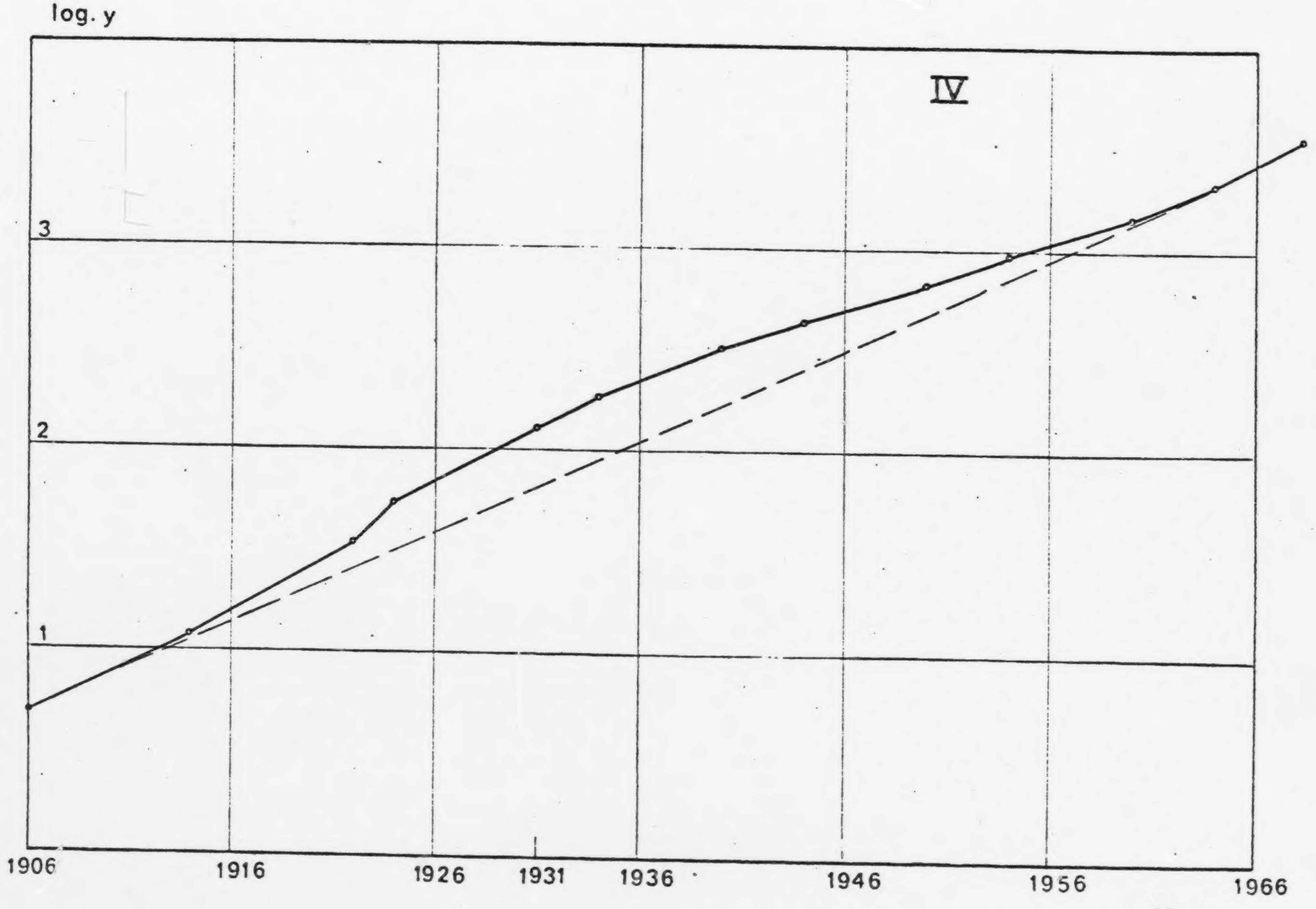
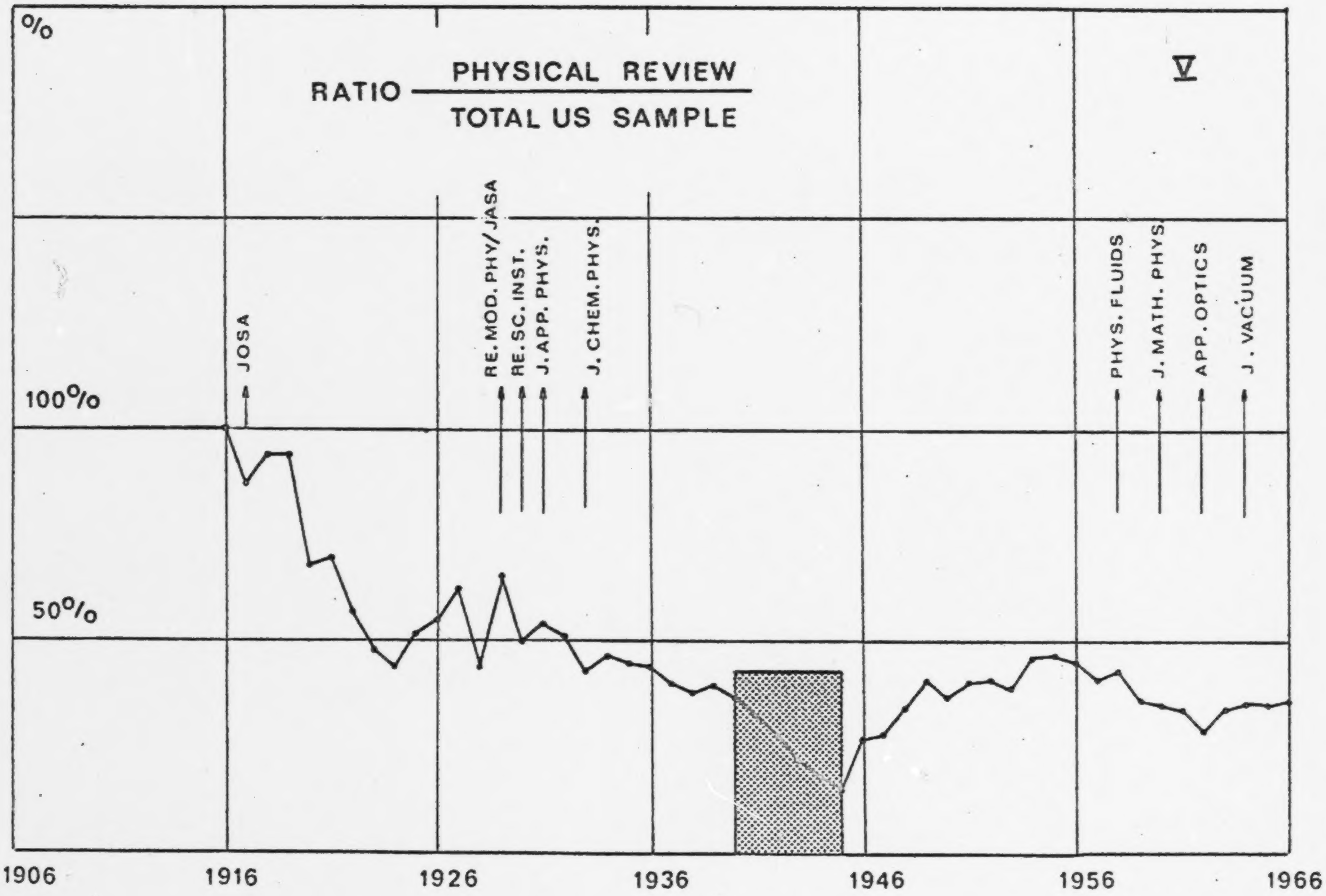
Number of pages published in 1964

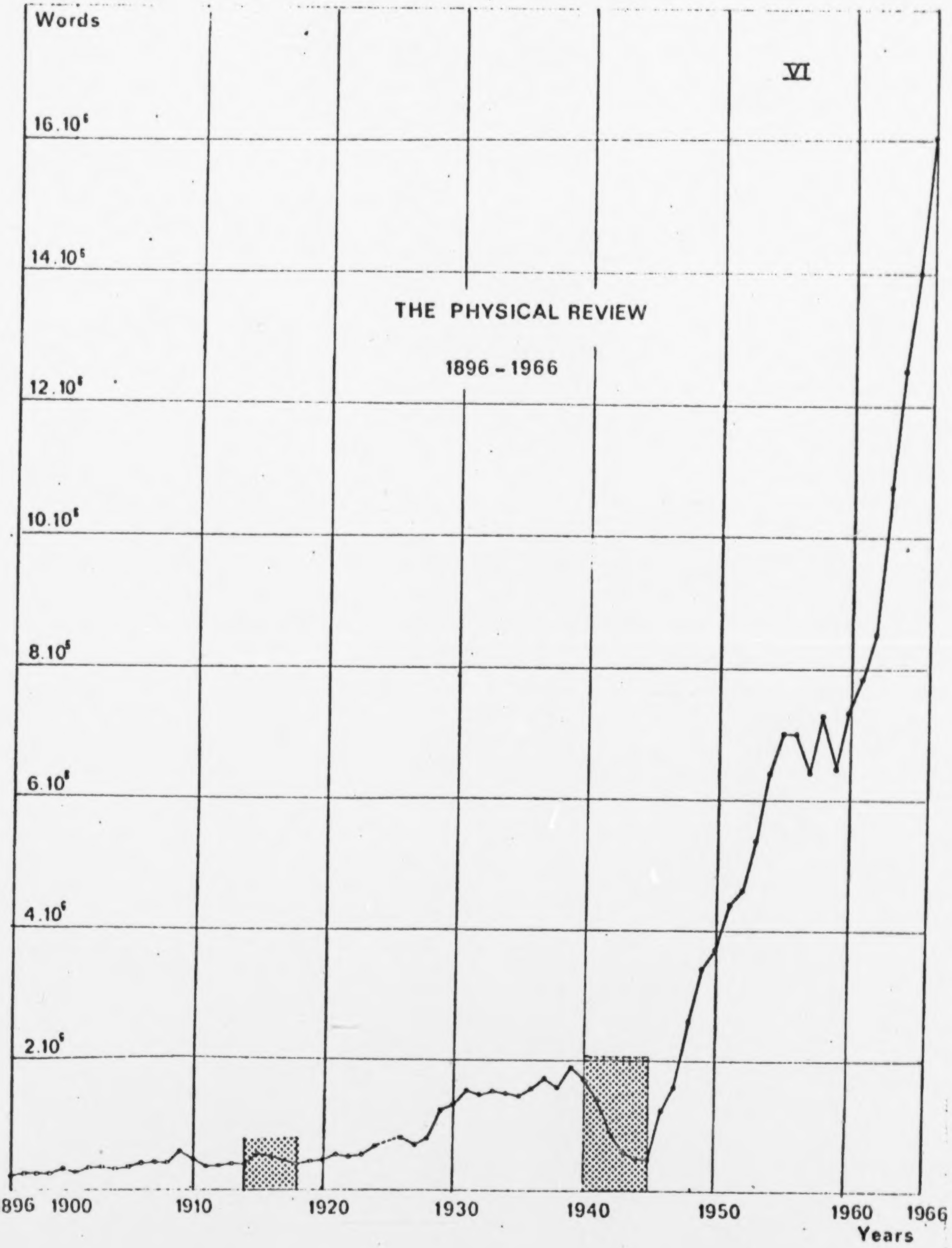


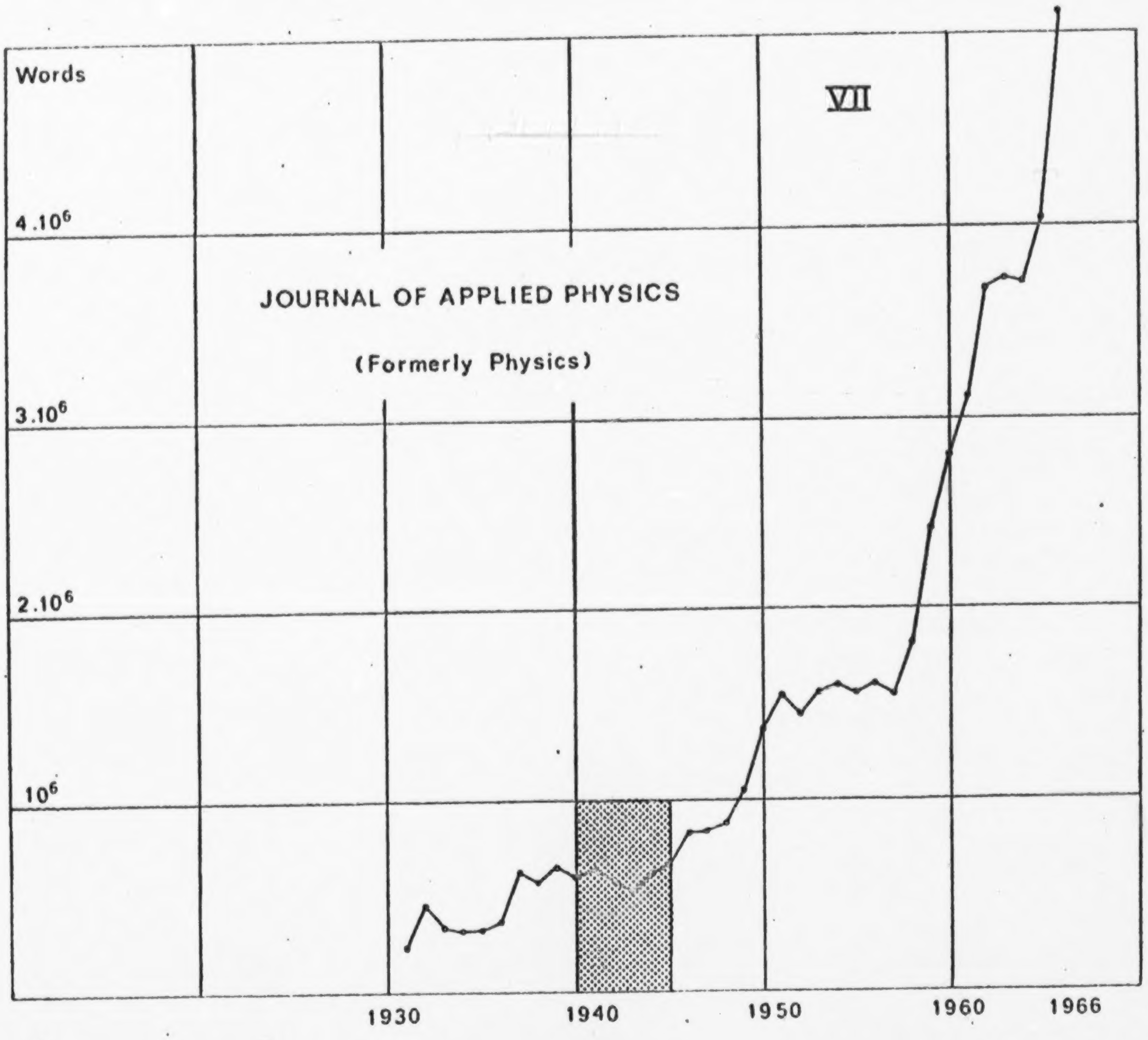
IIa
The A.I.P. SAMPLE·
1893 - 1966
Words
4.10⁷
3.10⁷
2.10⁷
10⁷
1st World War
2d World War
1896
1900
1910
1920
1930
1940
1950
1960
1966
Years
IIb
Words
6.10⁵
5.10⁵
4.10⁵
3.10⁵
2.10⁵
10⁵
Years
1895
1900
1905
1910
1915

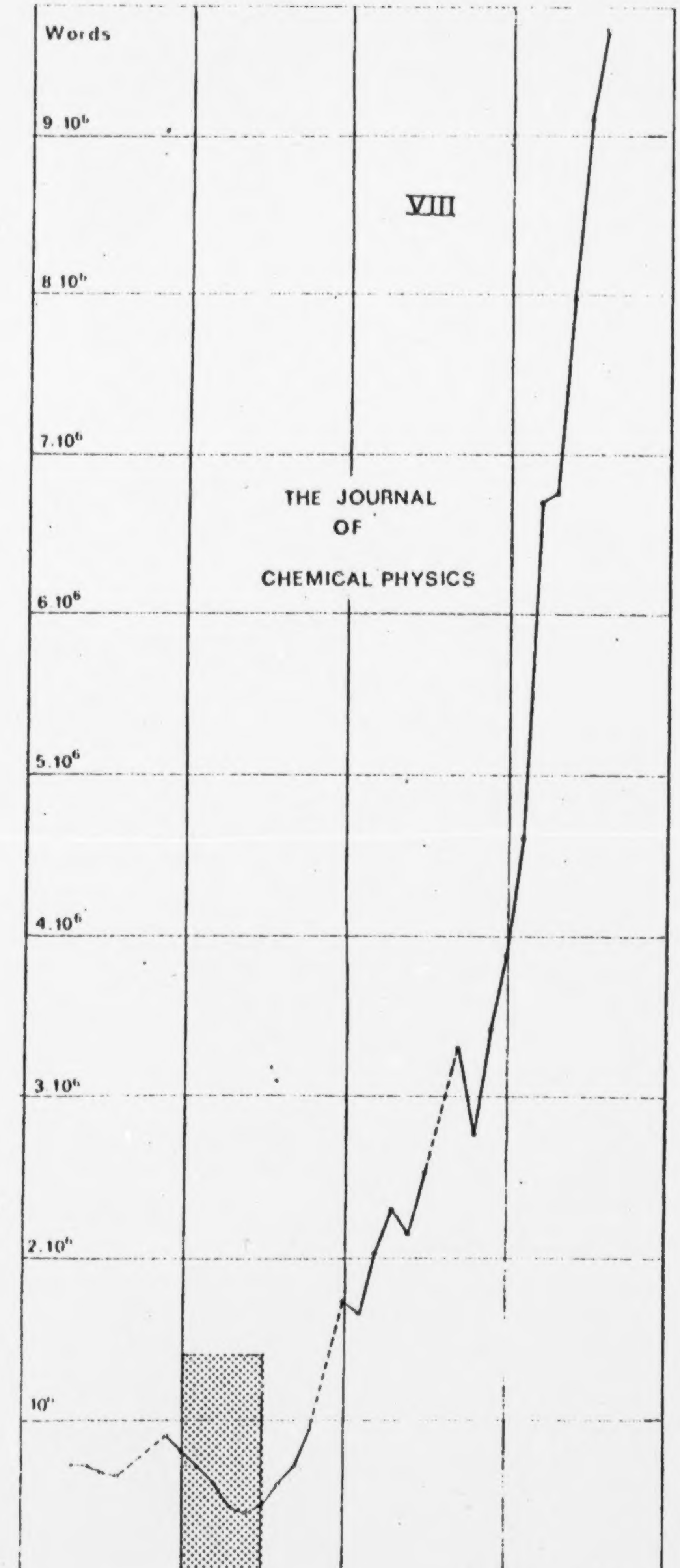

Words
III
A.I.P. SAMPLE :
"Smoothed" Curve
4 10⁷
3 10⁷
2 10⁷
10⁷
1896
1900
1910
1920
1930
1940
1950
1960
1966
Years

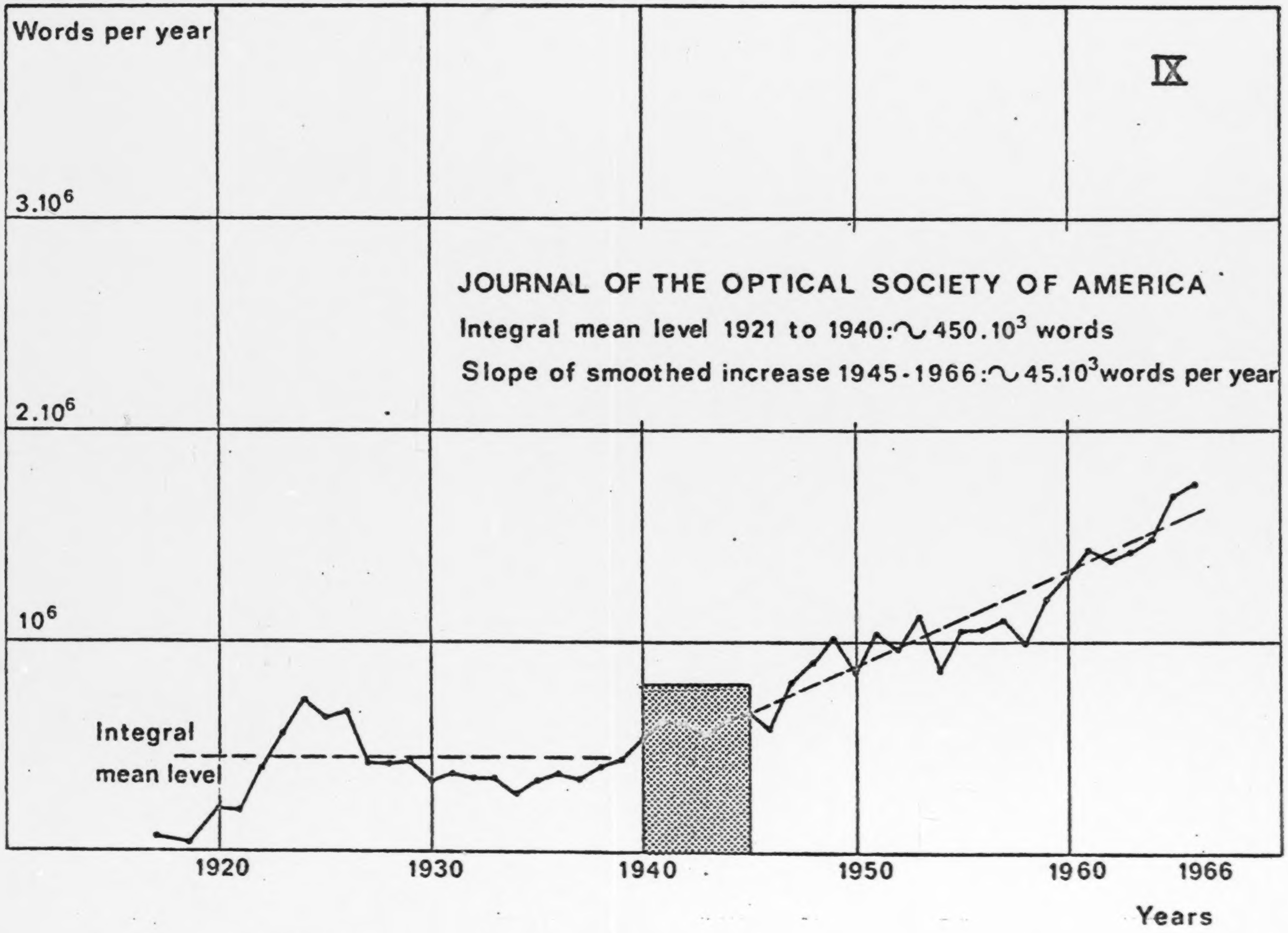

log. y
IV
3
2
1
1906
1916
1926
1931
1936
1946
1956
1966
Years

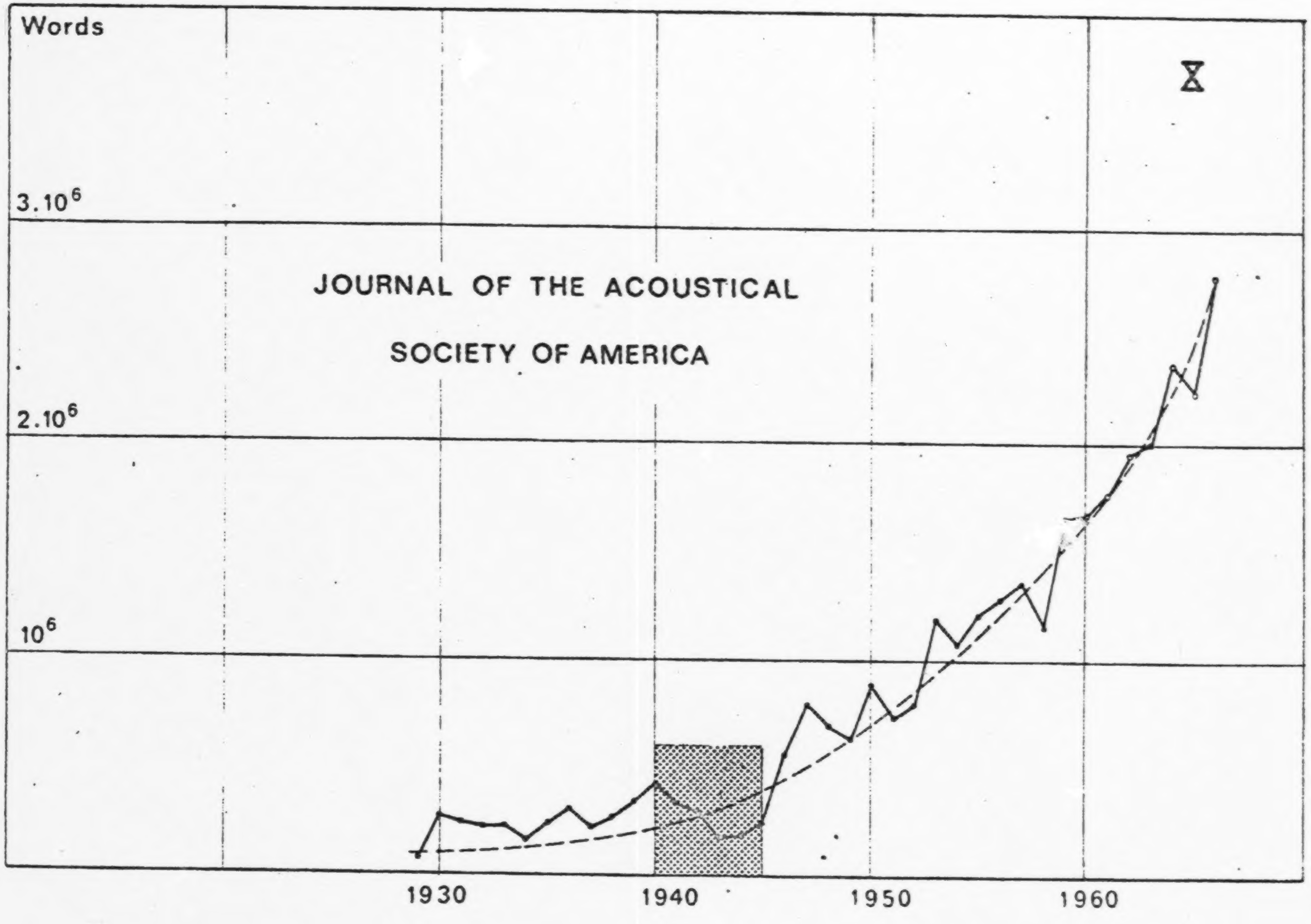

%
RATIO PHYSICAL REVIEW / TOTAL US SAMPLE
V
100%
50%
JOSA
RE. MOD. PHY/ JASA
RE. SC. INST.
J. APP. PHYS.
J. CHEM. PHYS.
PHYS. FLUIDS
J. MATH. PHYS.
APP. OPTICS
J. VACUUM
1906
1916
1926
1936
1946
1956
1966

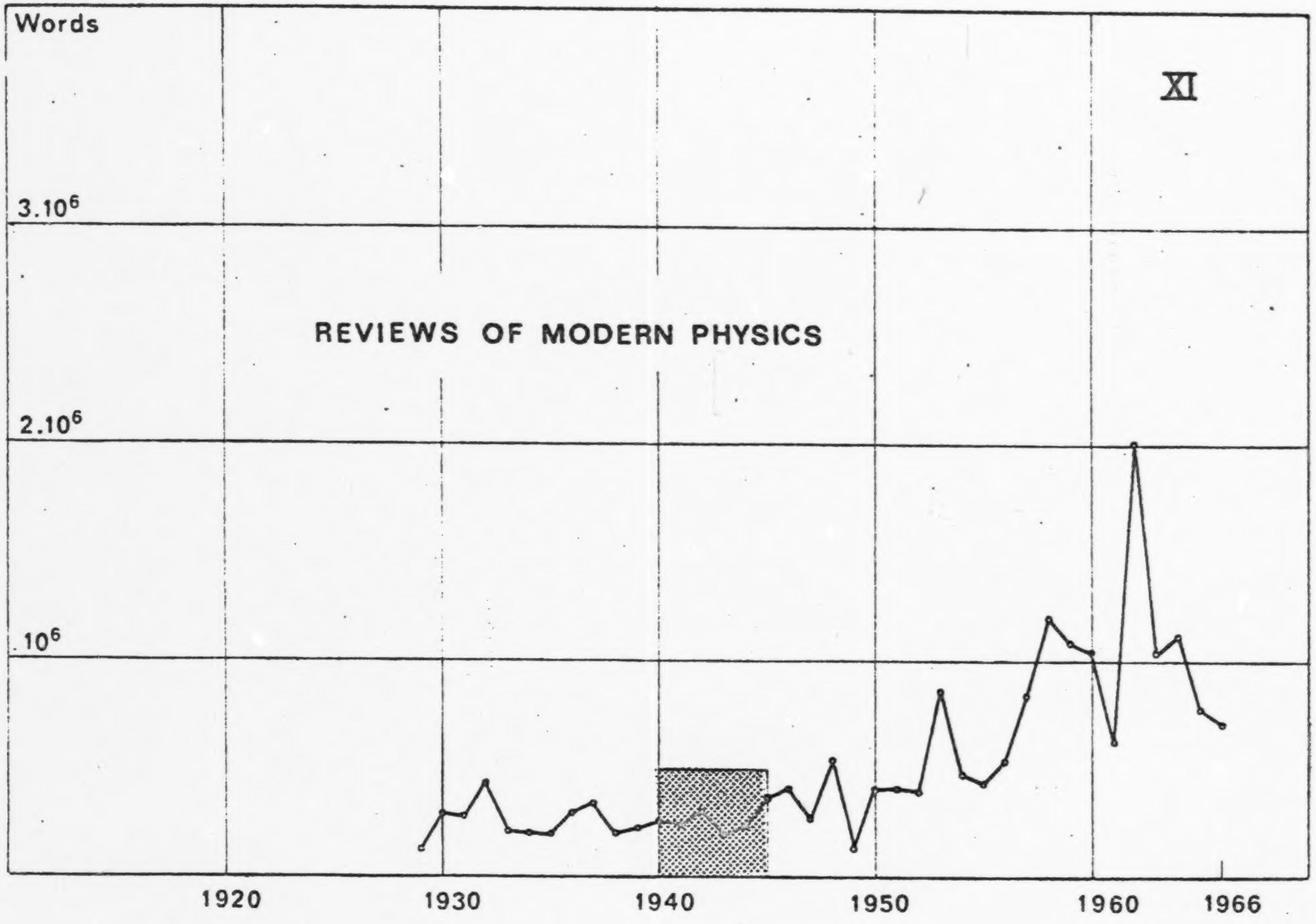

Words
VI
16.10⁶
14.10⁶
12.10⁶
10.10⁶
8.10⁶
6.10⁶
4.10⁶
2.10⁶
THE PHYSICAL REVIEW
1896 - 1966
1896
1900
1910
1920
1930
1940
1950
1960
1966
Years


Words
VII
4.10⁶
JOURNAL OF APPLIED PHYSICS
(Formerly Physics)
3.10⁶
2.10⁶
10⁶
1930
1940
1950
1960
1966


Words
9.10⁶
VIII
8.10⁶
7.10⁶
THE JOURNAL
OF
CHEMICAL PHYSICS
6.10⁶
5.10⁶
4.10⁶
3.10⁶
2.10⁶
10⁶
1930
1940
1950
1960


Words per year
IX
3.10⁶
2.10⁶
10⁶
JOURNAL OF THE OPTICAL SOCIETY OF AMERICA
Integral mean level 1921 to 1940: ∿ 450.10³ words
Slope of smoothed increase 1945-1966: ∿ 45.10³ words per year
Integral mean level
1920
1930
1940
1950
1960
1966
Years


Words
3.10^6
2.10^6
10^6
JOURNAL OF THE ACOUSTICAL
SOCIETY OF AMERICA
1930
1940
1950
1960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XI
3.10⁶
REVIEWS OF MODERN PHYSICS
2.10⁶
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1940
1950
1960
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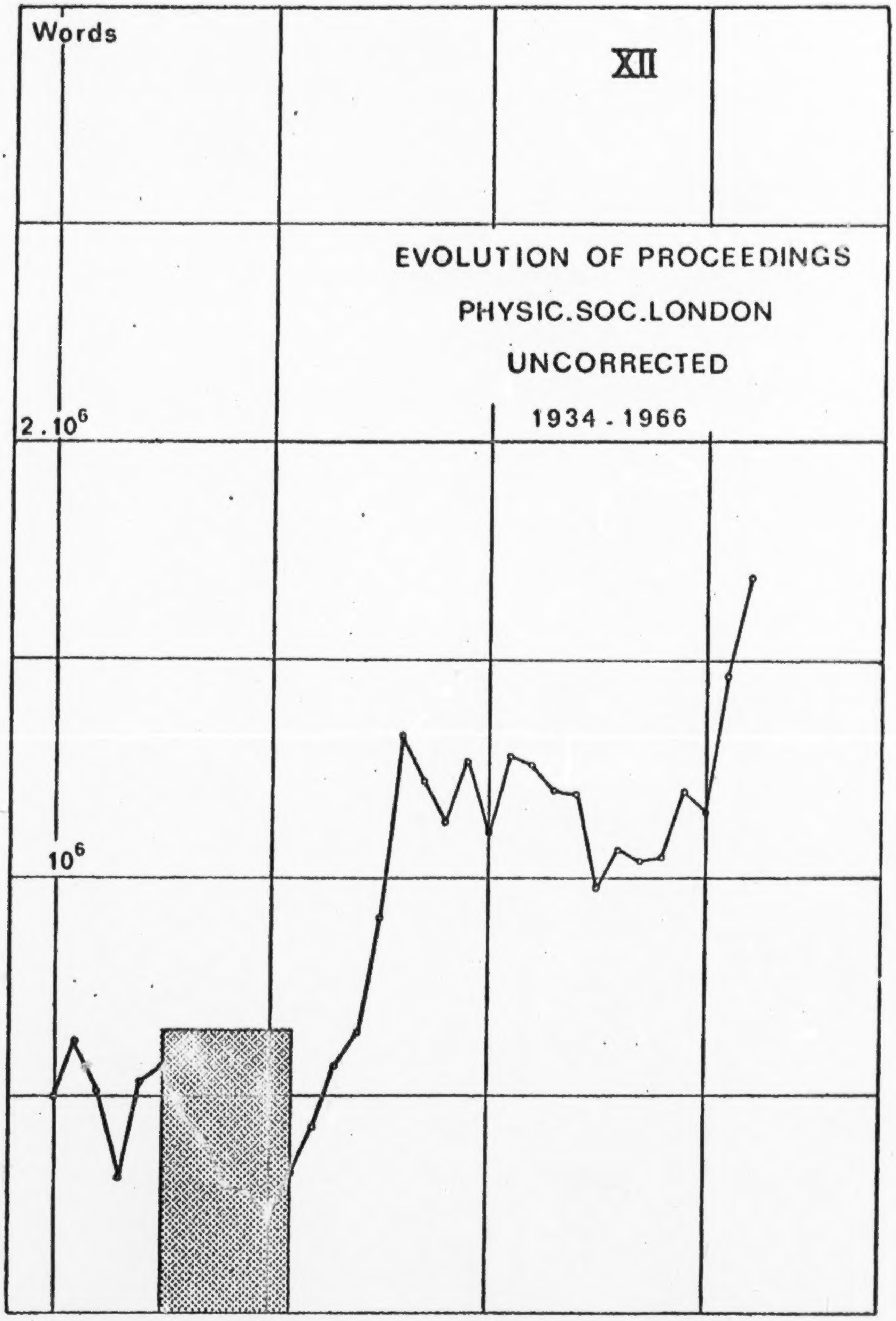
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XII
EVOLUTION OF PROCEEDINGS
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1934
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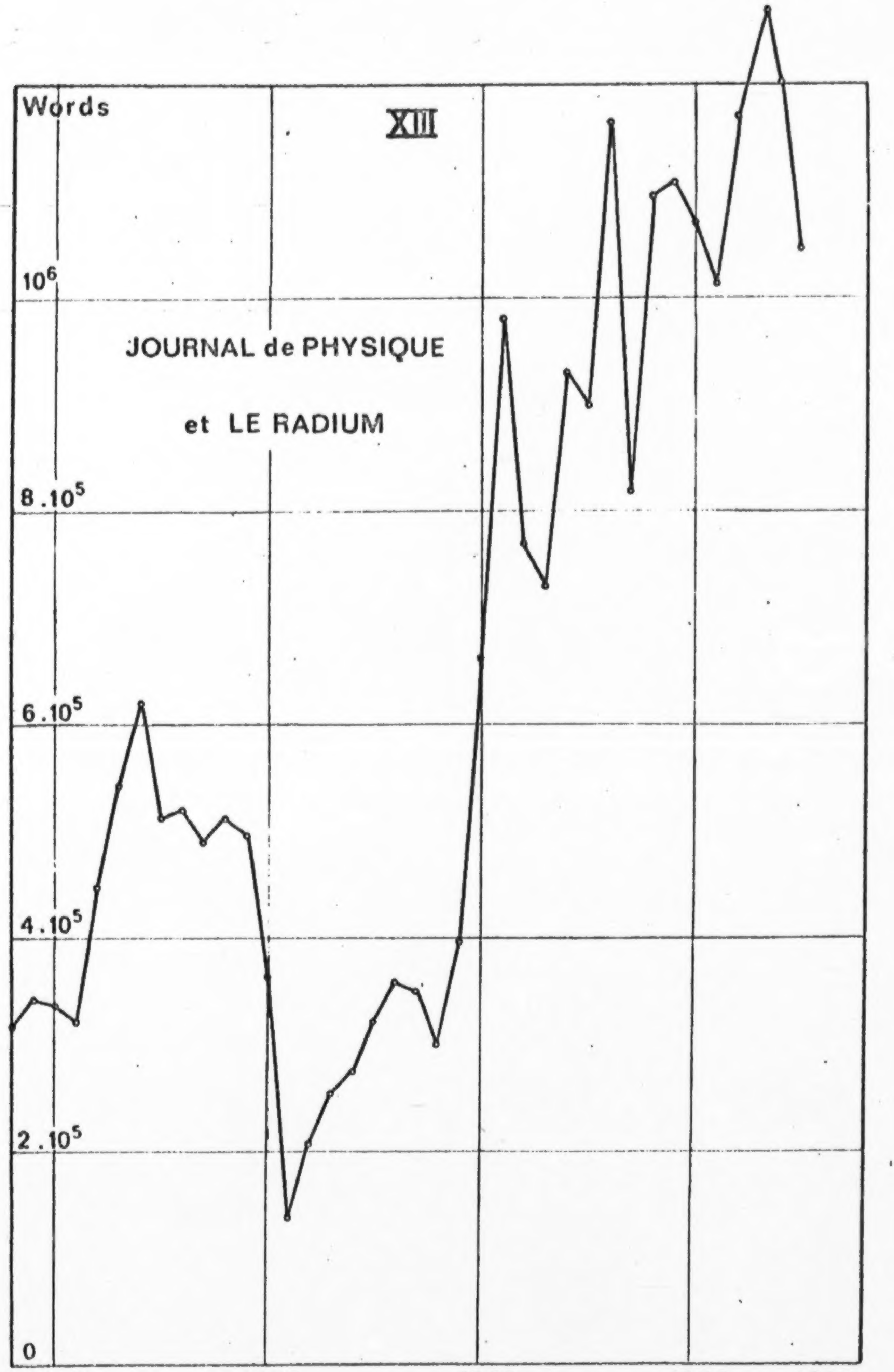
1954
1964


Words
XIII
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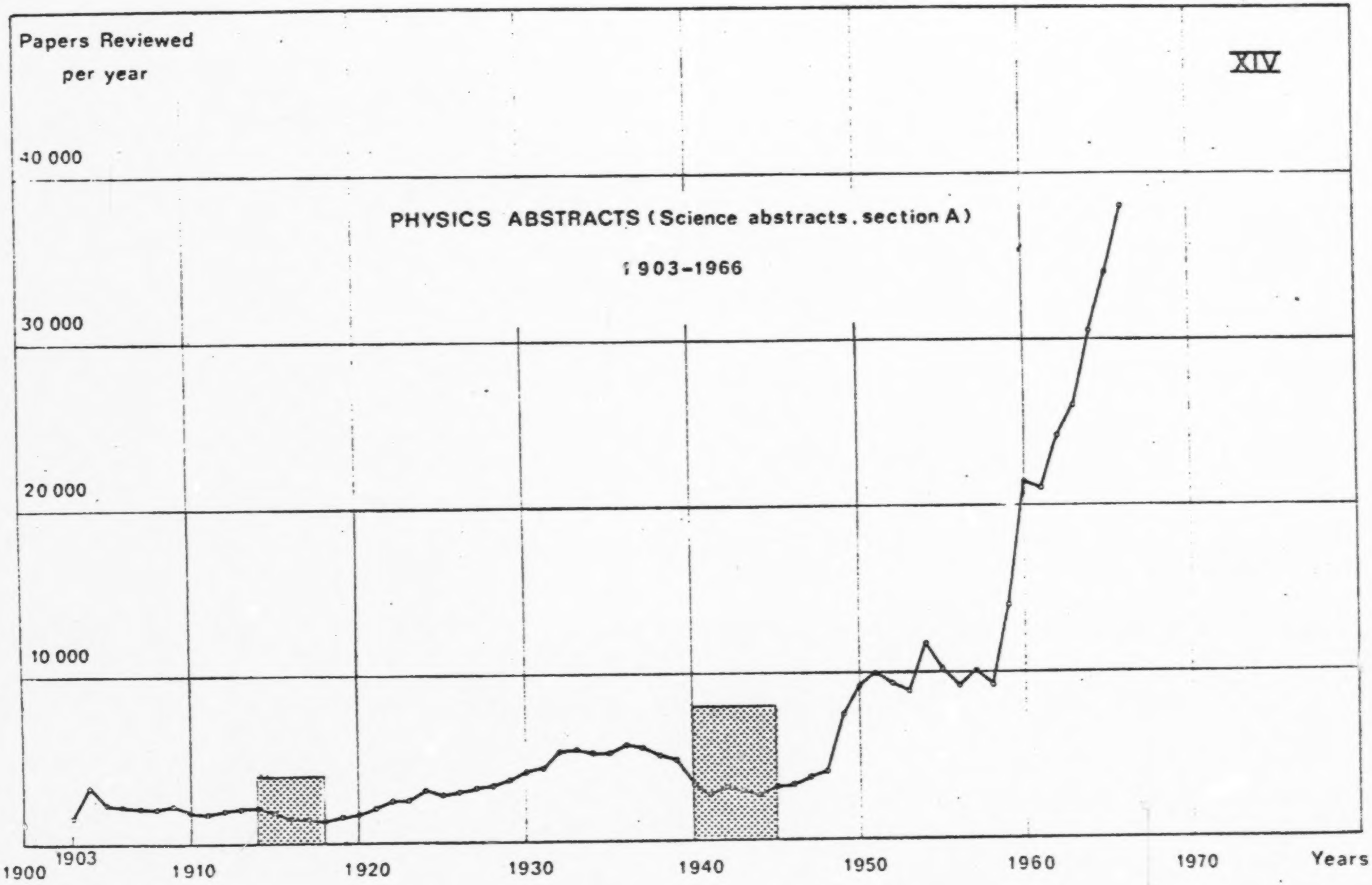
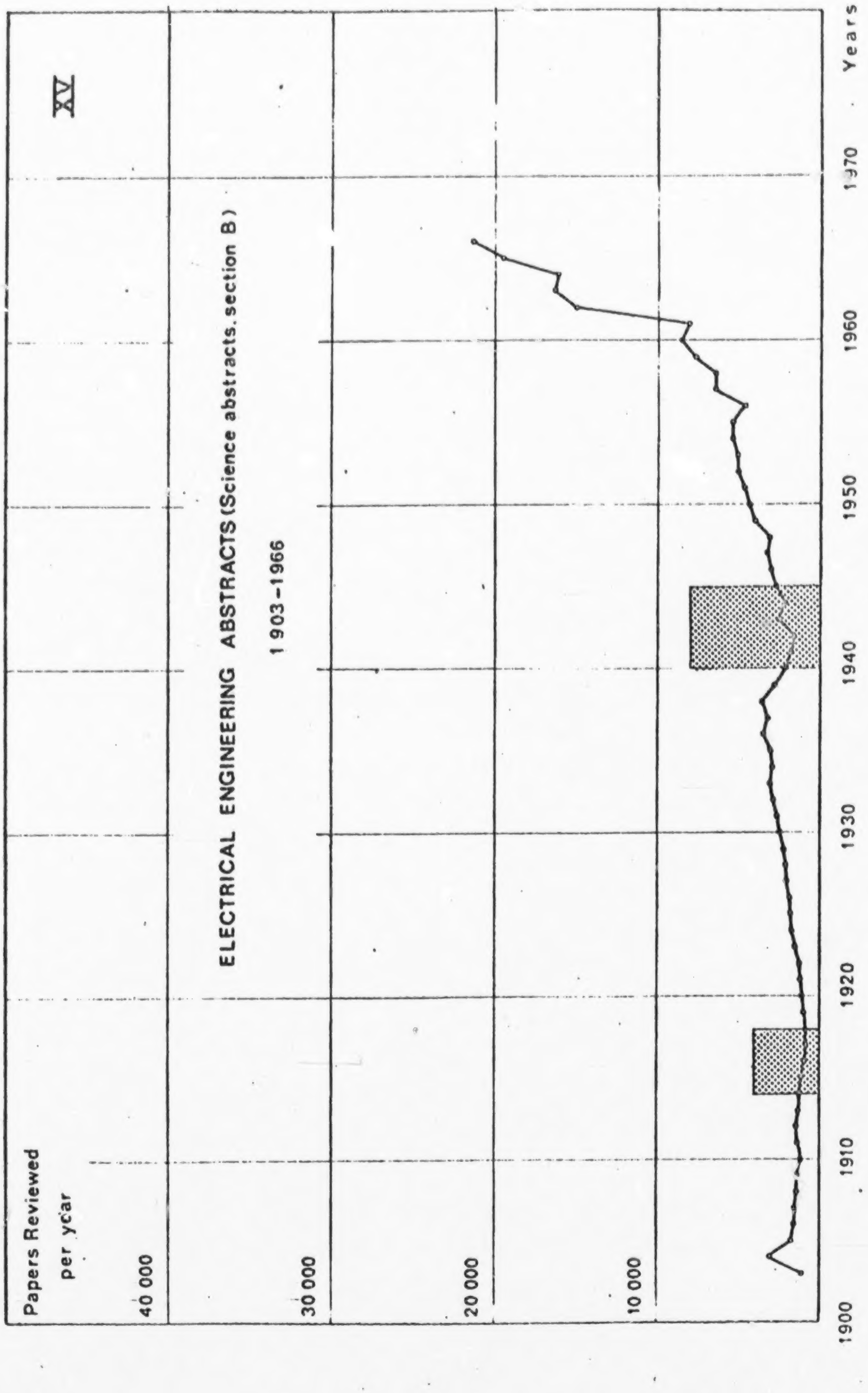
1950
1960
1965
Years



XIV

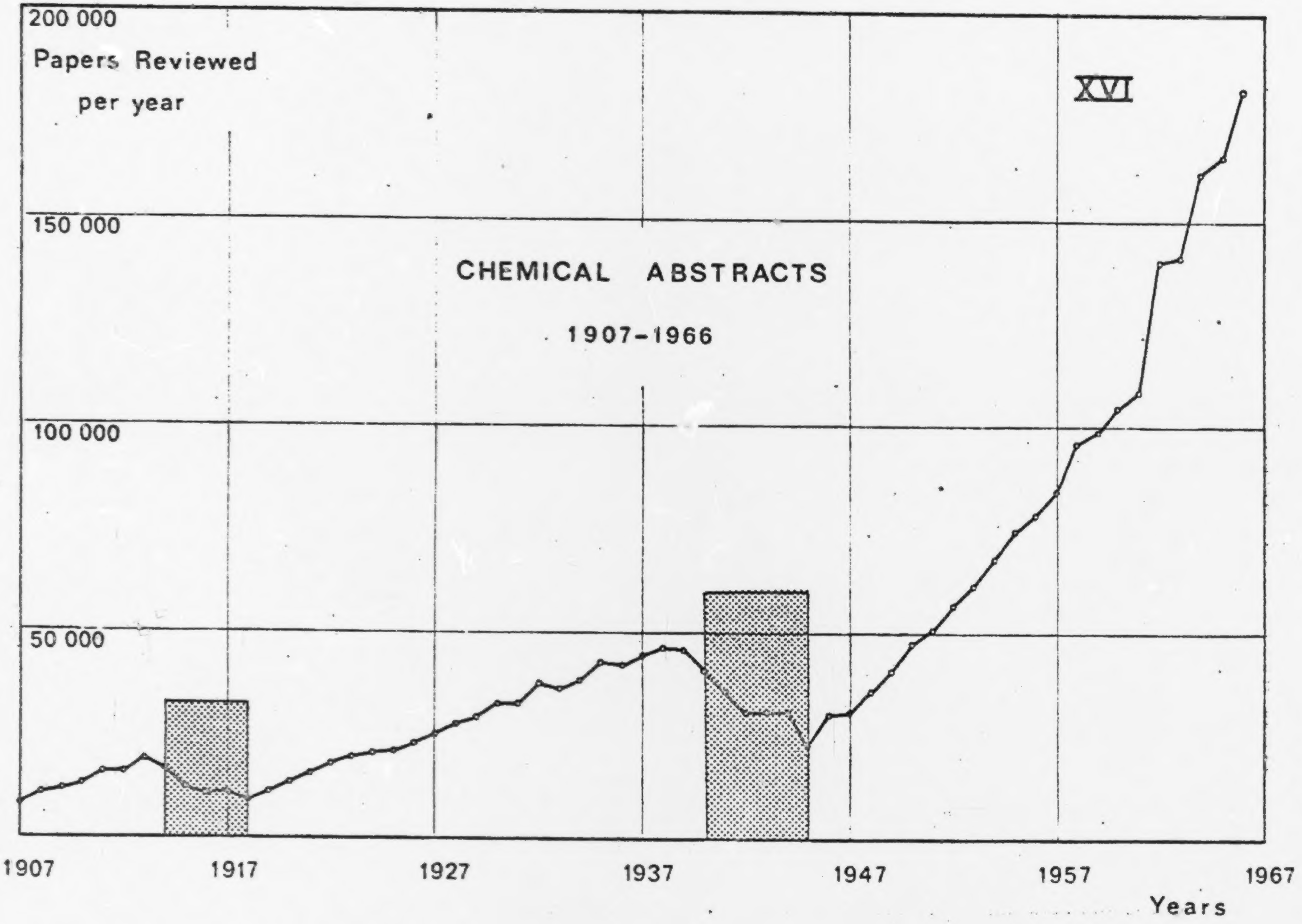
PHYSICS ABSTRACTS (Science abstracts. section A)

1903–1966



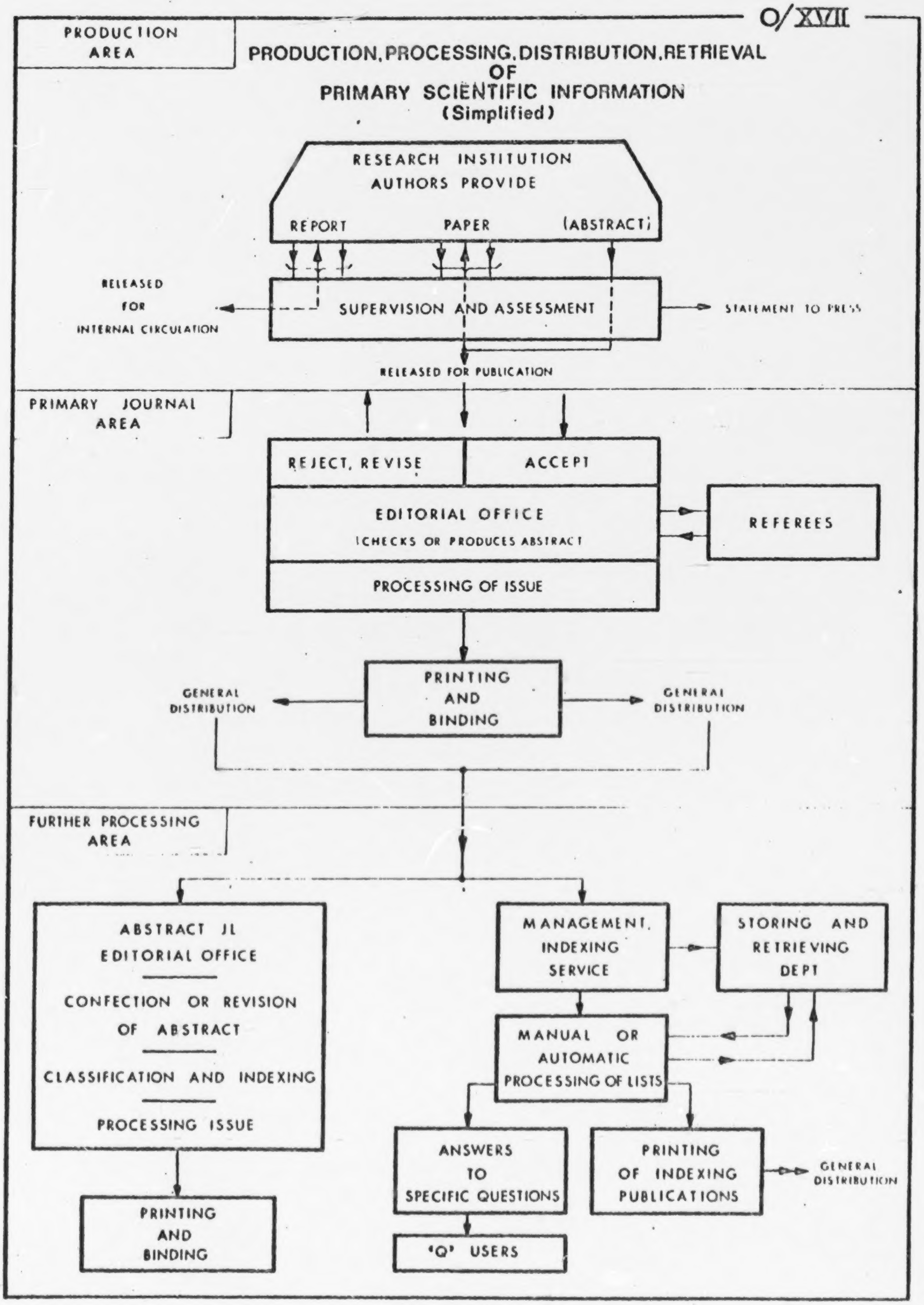
ELECTRICAL ENGINEERING ABSTRACTS (Science abstracts. section B)

1903–1966


XVI
CHEMICAL ABSTRACTS
1907-1966
200 000
Papers Reviewed
per year
150 000
100 000
50 000
1907
1917
1927
1937
1947
1957
1967
Years

O/XVII

PRODUCTION, PROCESSING, DISTRIBUTION, RETRIEVAL OF PRIMARY SCIENTIFIC INFORMATION (Simplified)


PRODUCTION AREA
RESEARCH INSTITUTION AUTHORS PROVIDE
REPORT
PAPER
(ABSTRACT)
RELEASED FOR INTERNAL CIRCULATION
SUPERVISION AND ASSESSMENT
STATEMENT TO PRESS
RELEASED FOR PUBLICATION
PRIMARY JOURNAL AREA
REJECT, REVISE
ACCEPT
EDITORIAL OFFICE
(CHECKS OR PRODUCES ABSTRACT
REFEREES
PROCESSING OF ISSUE
PRINTING AND BINDING
GENERAL DISTRIBUTION
GENERAL DISTRIBUTION
FURTHER PROCESSING AREA
ABSTRACT JL EDITORIAL OFFICE
CONFECTION OR REVISION OF ABSTRACT
CLASSIFICATION AND INDEXING
PROCESSING ISSUE
PRINTING AND BINDING
MANAGEMENT, INDEXING SERVICE
STORING AND RETRIEVING DEPT
MANUAL OR AUTOMATIC PROCESSING OF LISTS
ANSWERS TO SPECIFIC QUESTIONS
'Q' USERS
PRINTING OF INDEXING PUBLICATIONS
GENERAL DISTRIBUTION